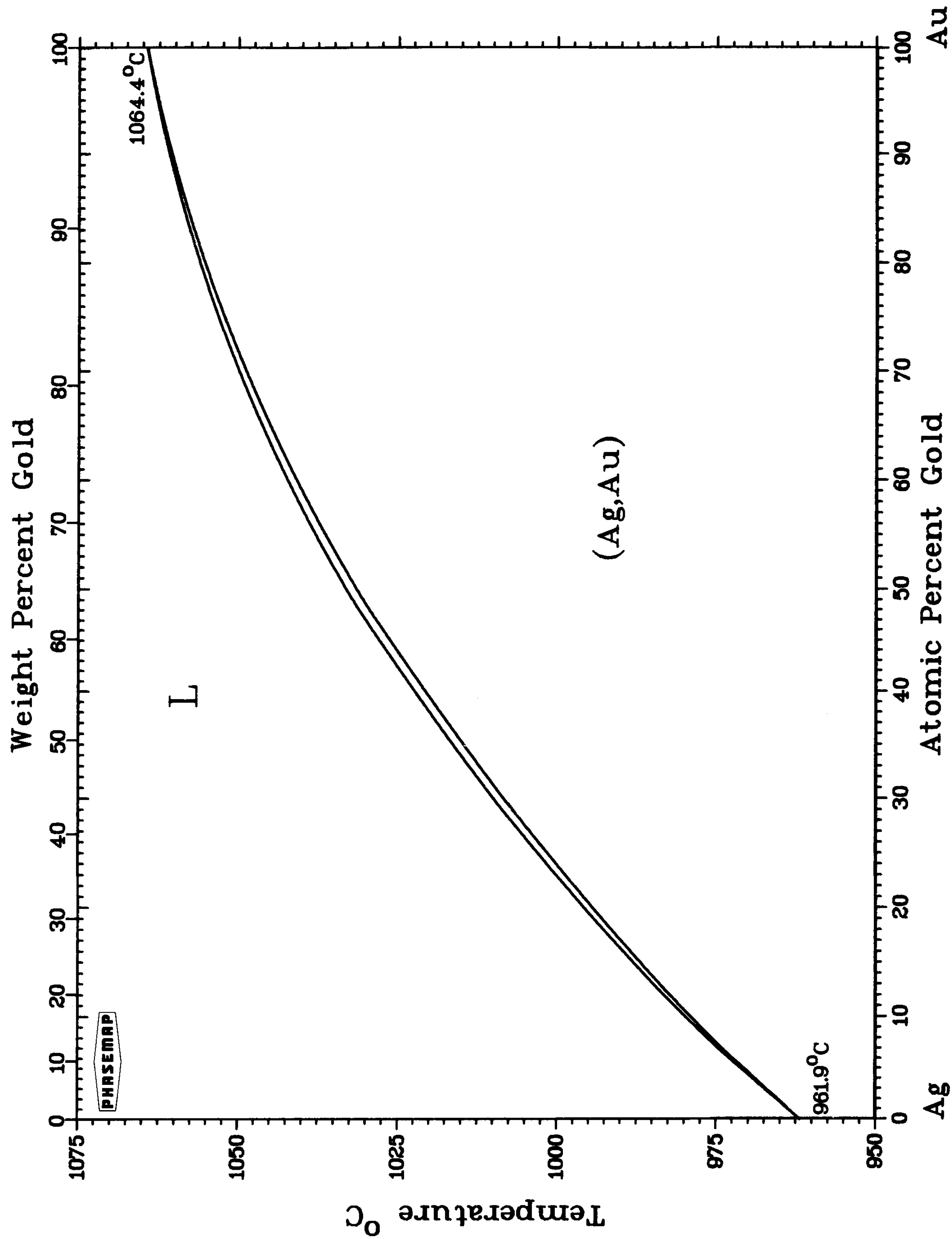
Tear-Out Pages

Pages in this section have been marked for removal and for punching for loose-leaf assembly, if desired.

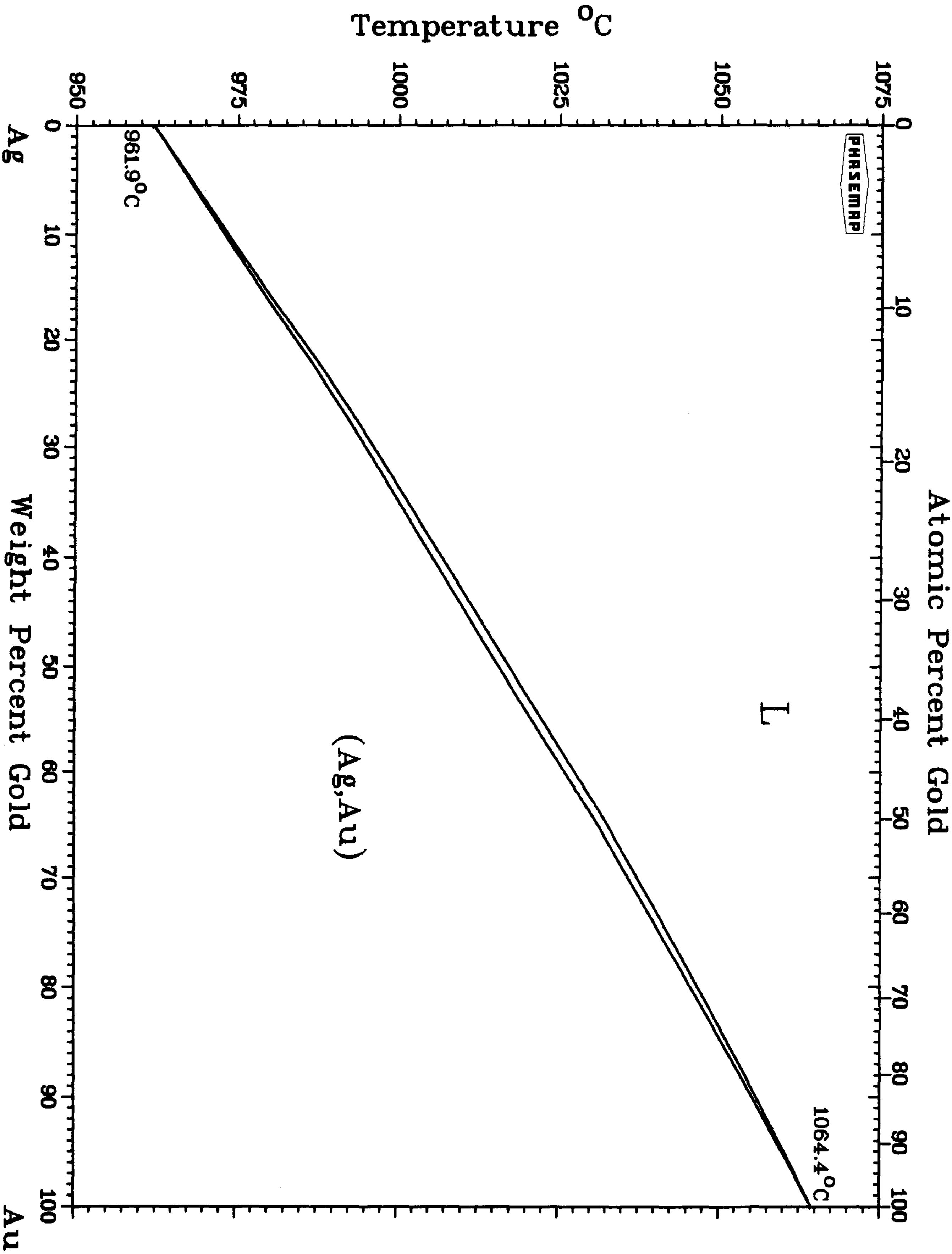
Alloy Phase Diagrams

The following section contains full-page, computer-generated phase diagrams for the alloy systems listed below. Also listed are the issue and page where the complete evaluation may be found.

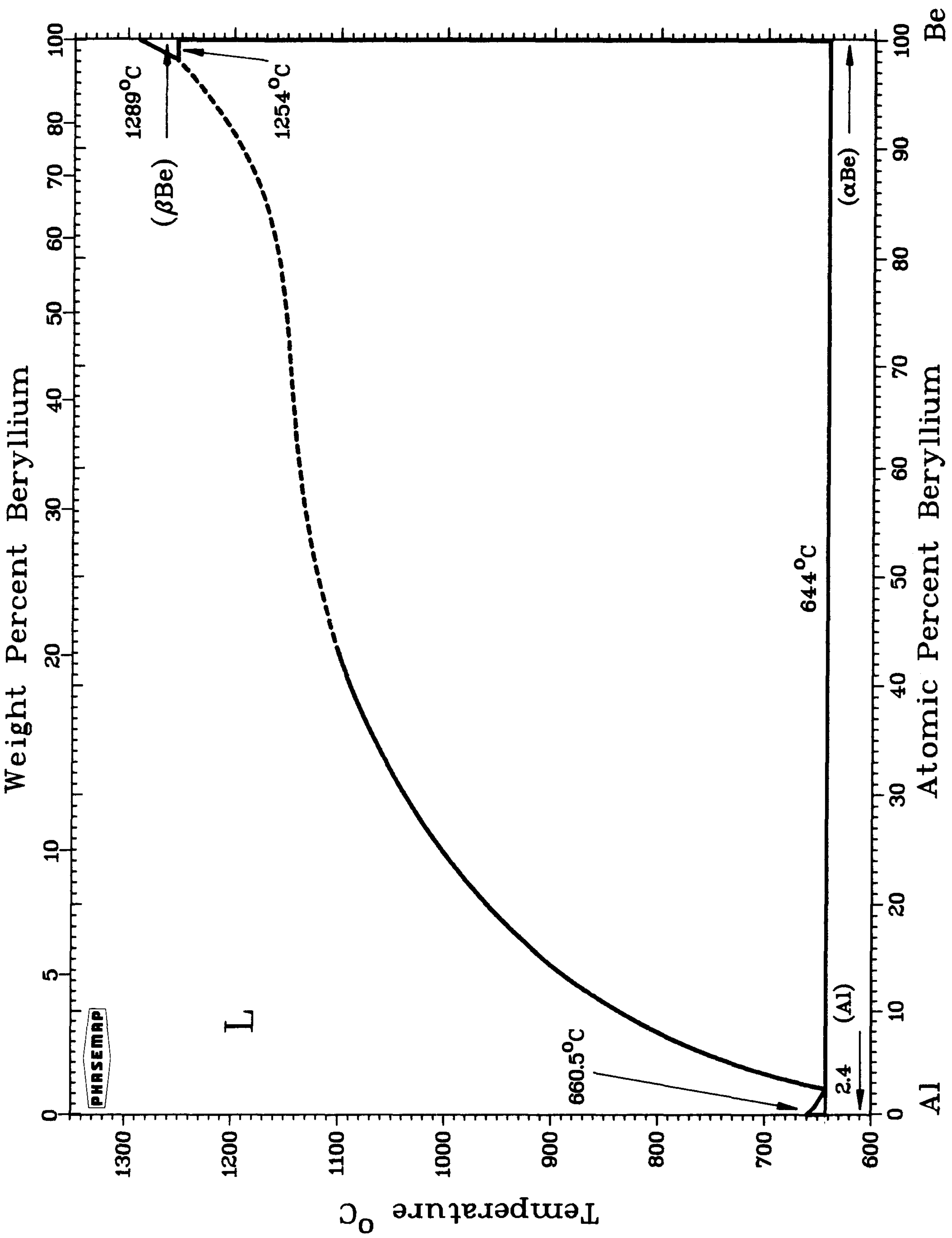
Properties of the Elements



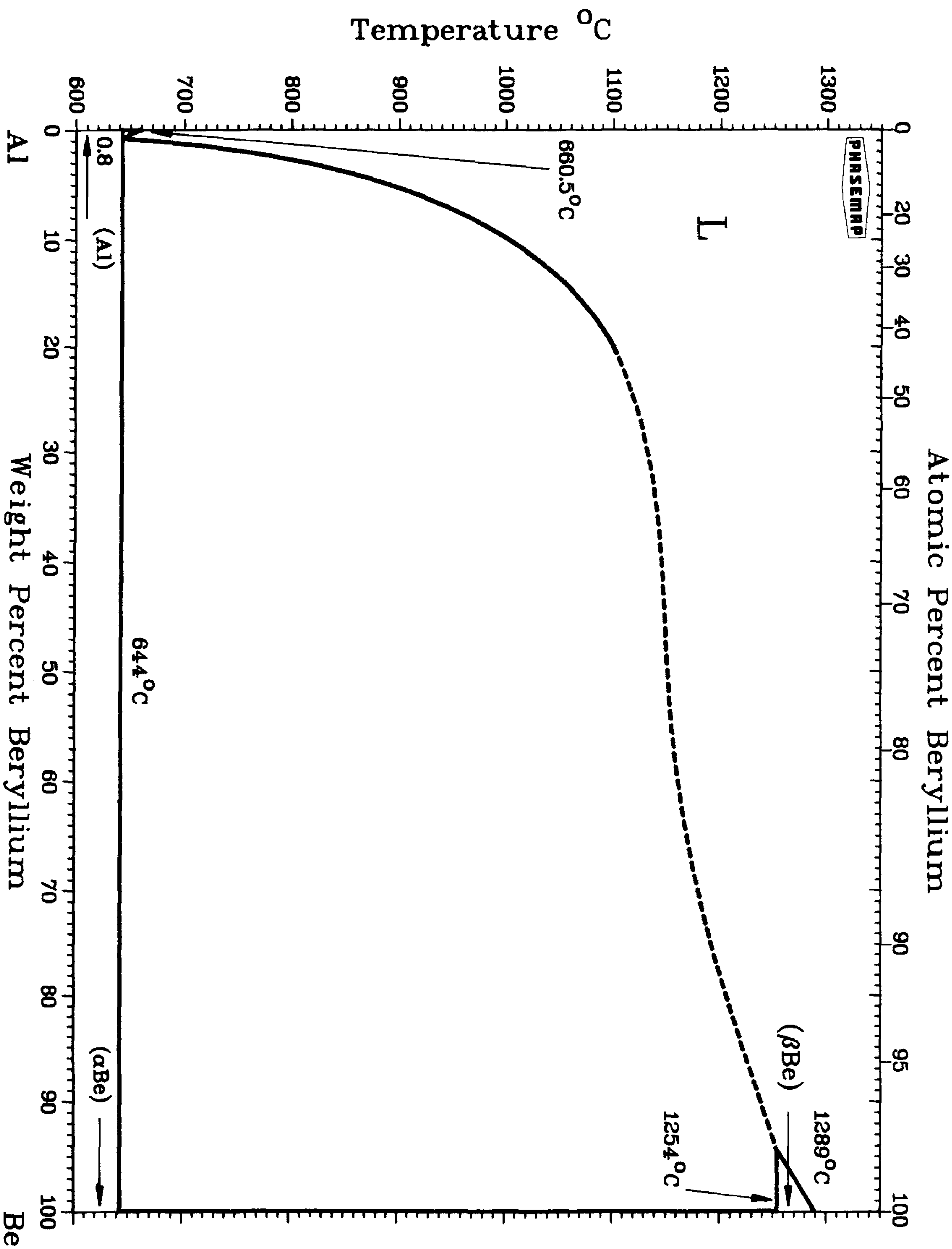
H. Okamoto and **T.B. Massalski;** evaluation on p 30 in this issue.
T.B. Massalski is Category Editor for binary gold alloys.



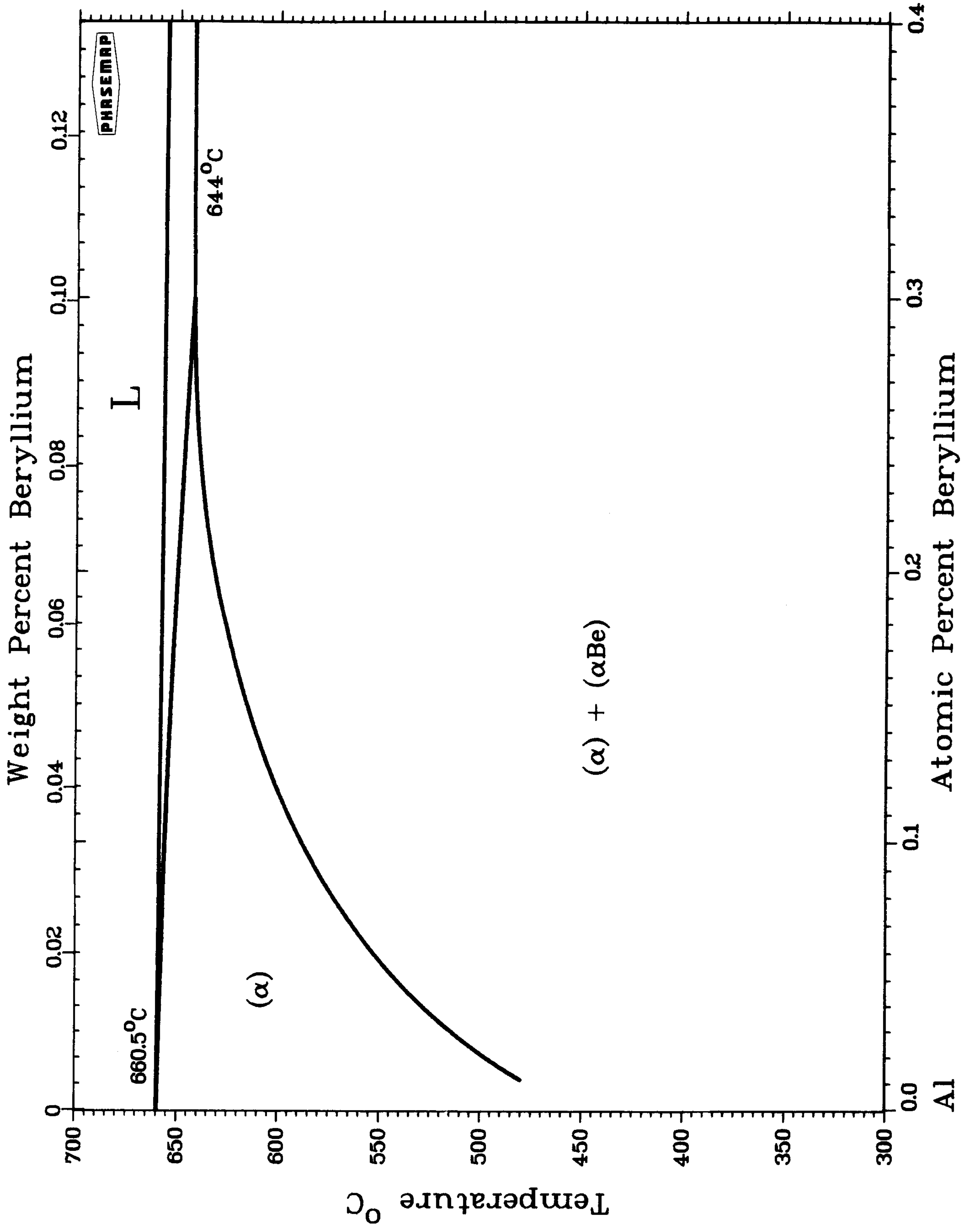
H. Okamoto and **T. B. Massalski;** evaluation on p 30 in this issue.
T. B. Massalski is Category Editor for binary gold alloys.



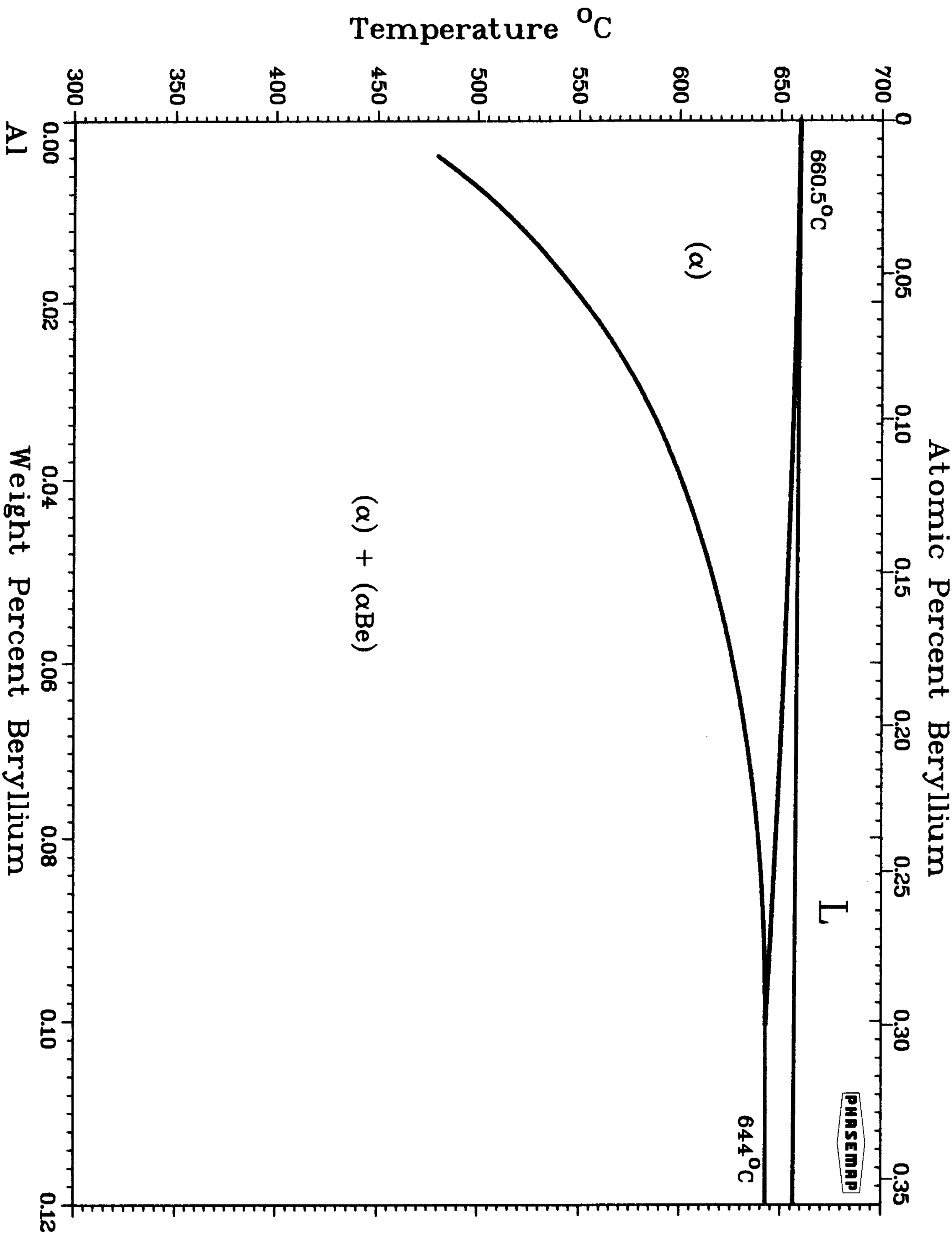
J. L. Murray and **D. J. Kahan**; evaluation on p 50 in this issue.
J. L. Murray is Co-Category Editor for binary aluminum alloys.



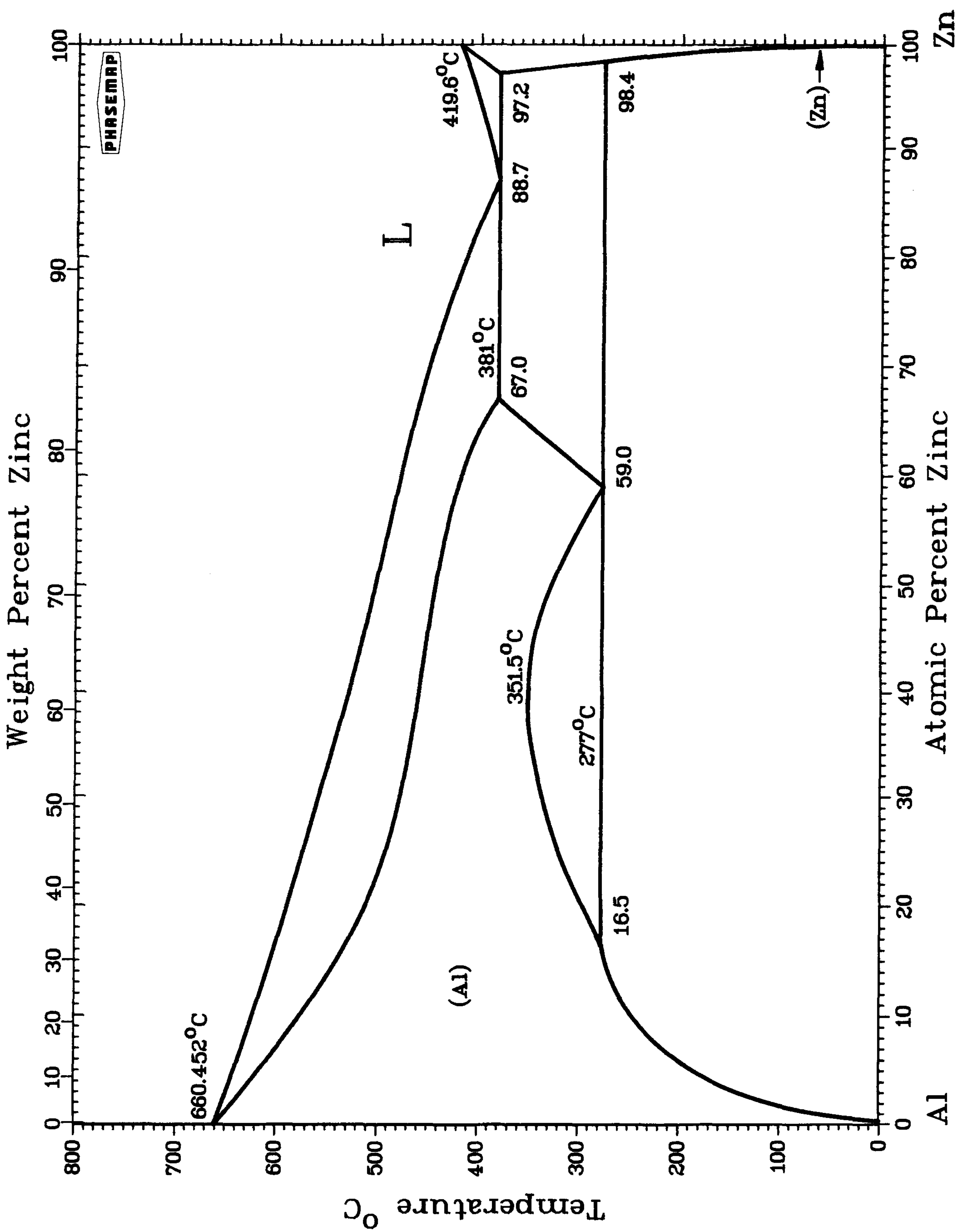
J. L. Murray and **D. J. Kahan**; evaluation on p 50 in this issue.
J. L. Murray is Co-Category Editor for binary aluminum alloys.



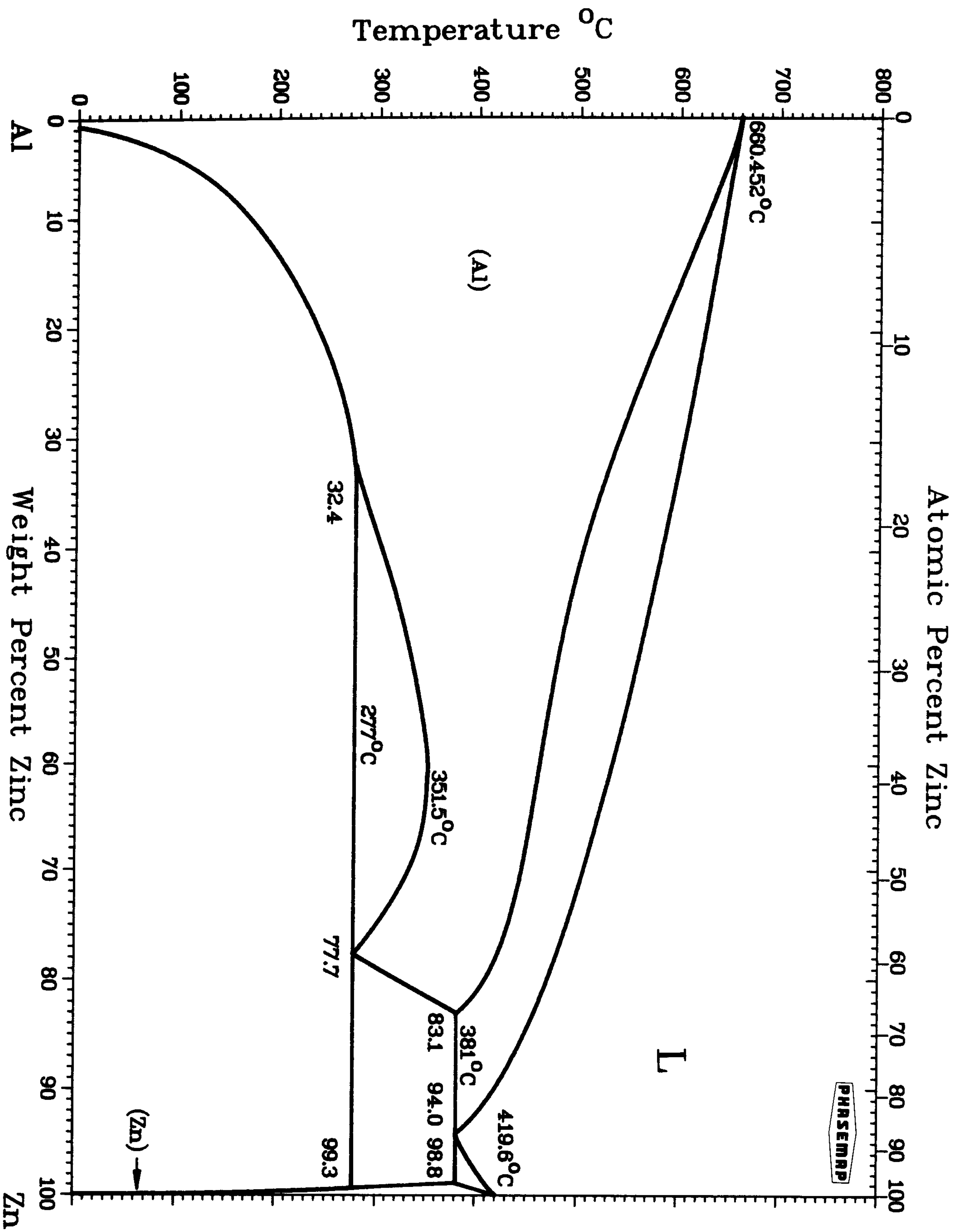
J. L. Murray and **D. J. Kahan**; evaluation on p 50 in this issue.
J. L. Murray is Co-Category Editor for binary aluminum alloys.



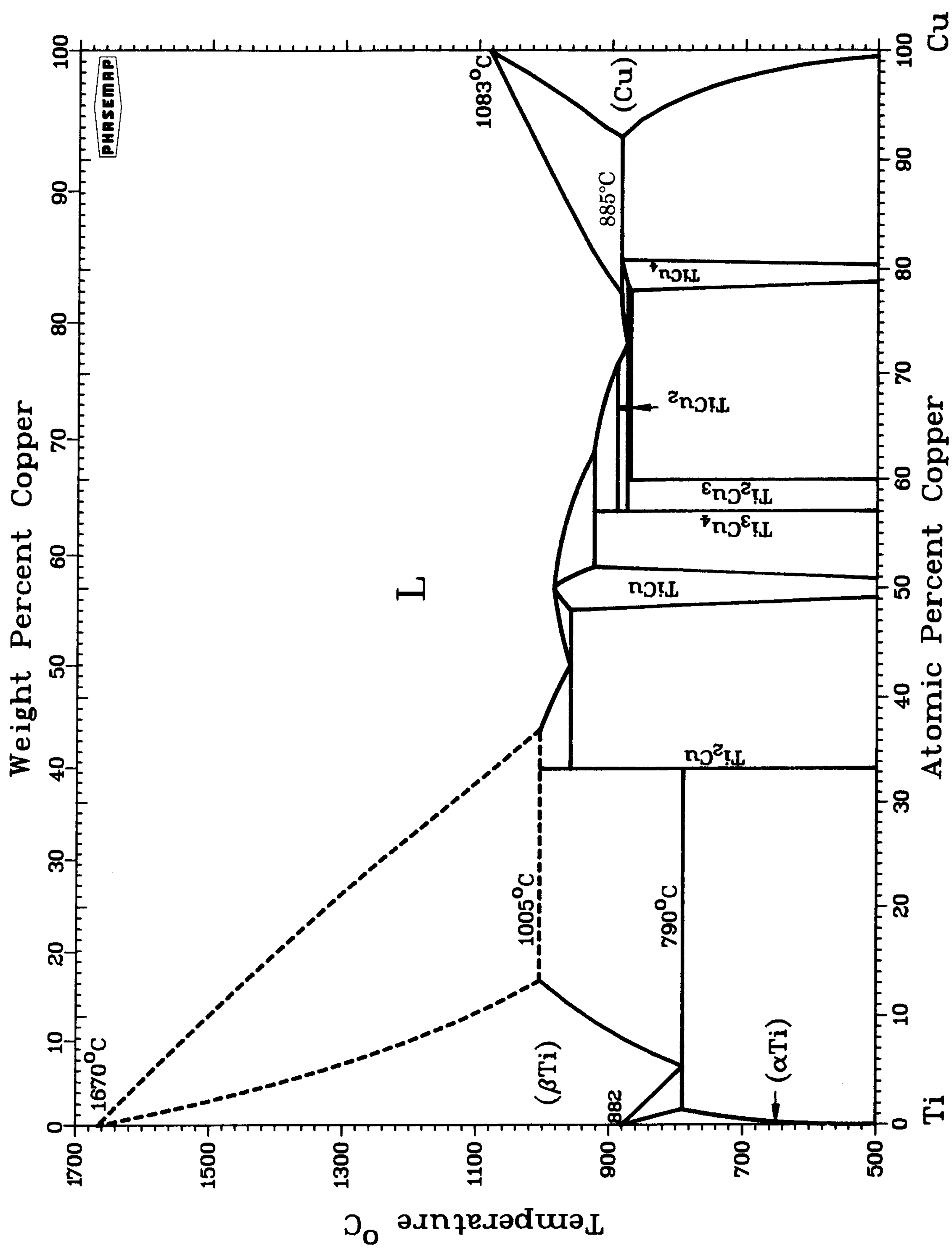
J. L. Murray and **D. J. Kahan;** evaluation on p 50 in this issue.
J. L. Murray is Co-Category Editor for binary aluminum alloys.



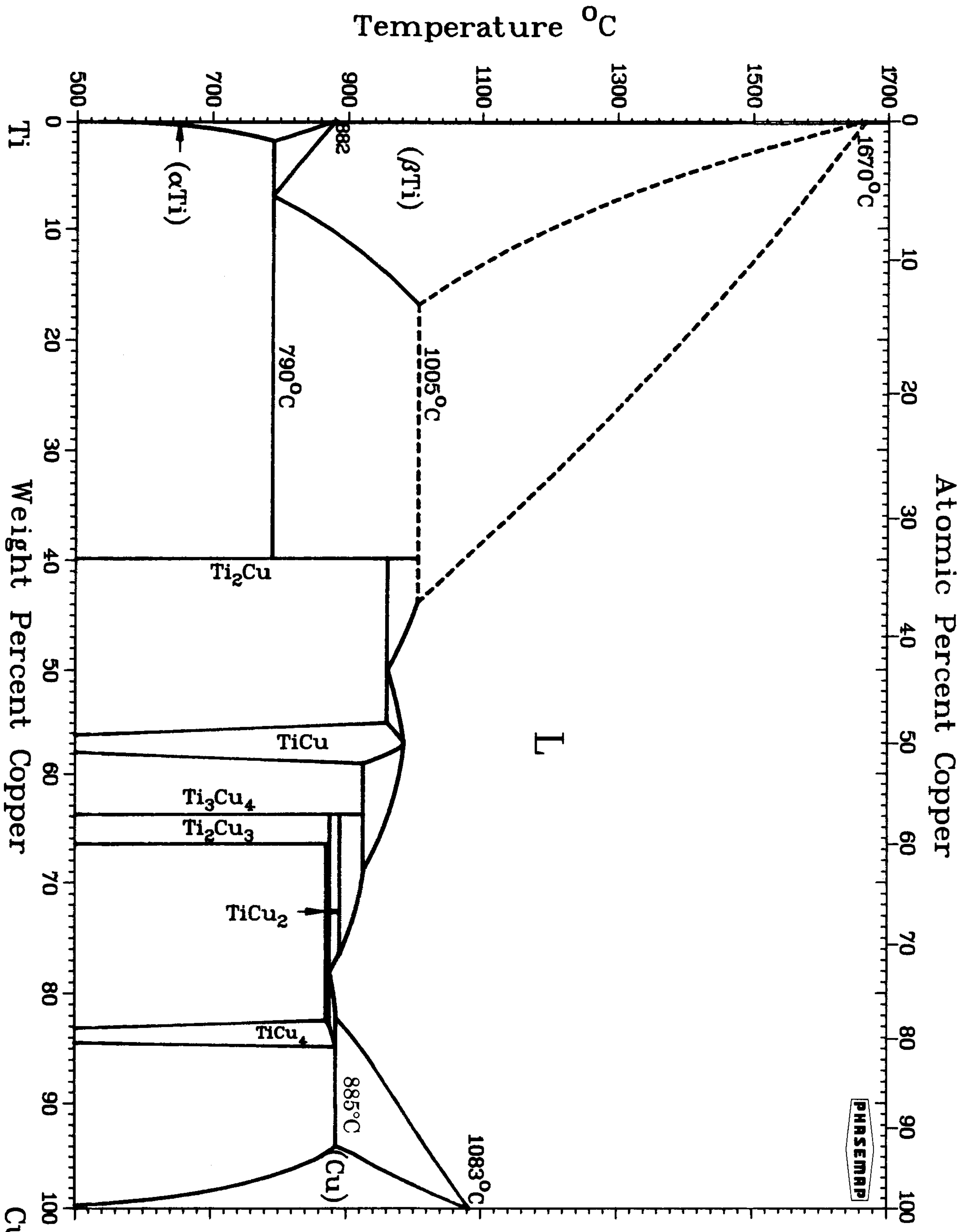
J. L. Murray; evaluation on p 55 in this issue.
J. L. Murray is Co-Category Editor for binary aluminum alloys.



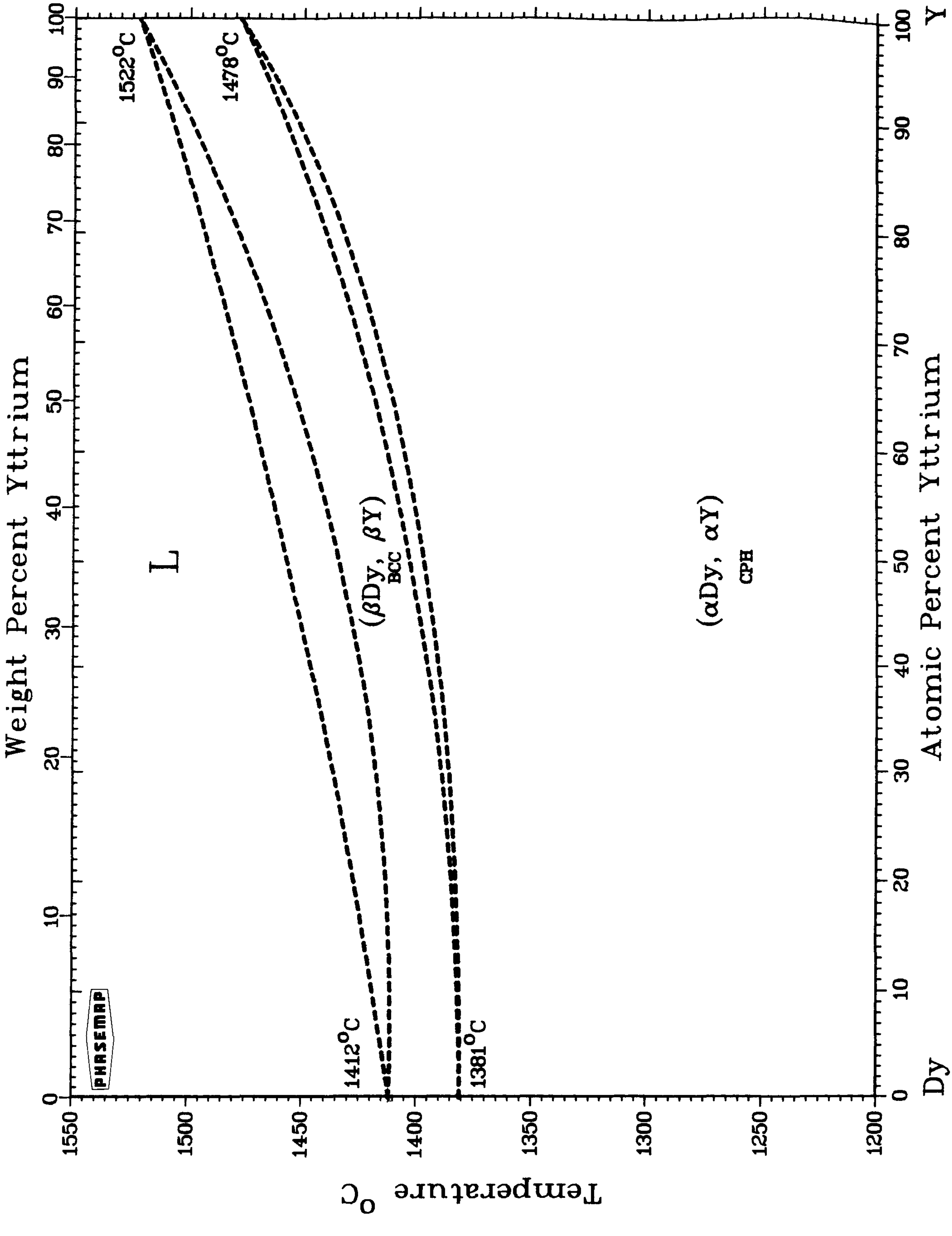
J. L. Murray; evaluation on p 55 in this issue.
J. L. Murray is Co-Category Editor for binary aluminum alloys.



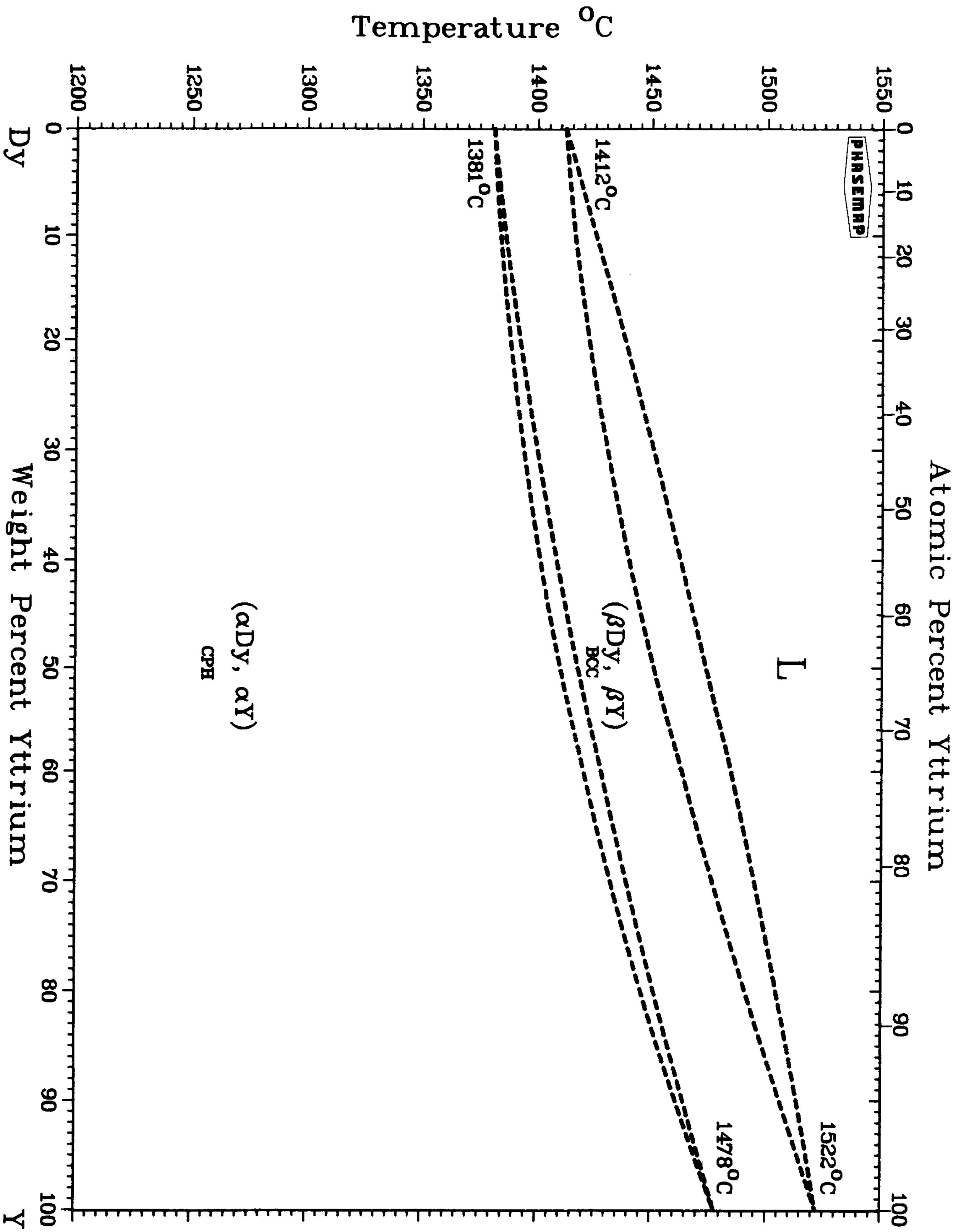
J.L. Murray; evaluation on p 81 in this issue.
J.L. Murray is Category Editor for binary titanium alloys.



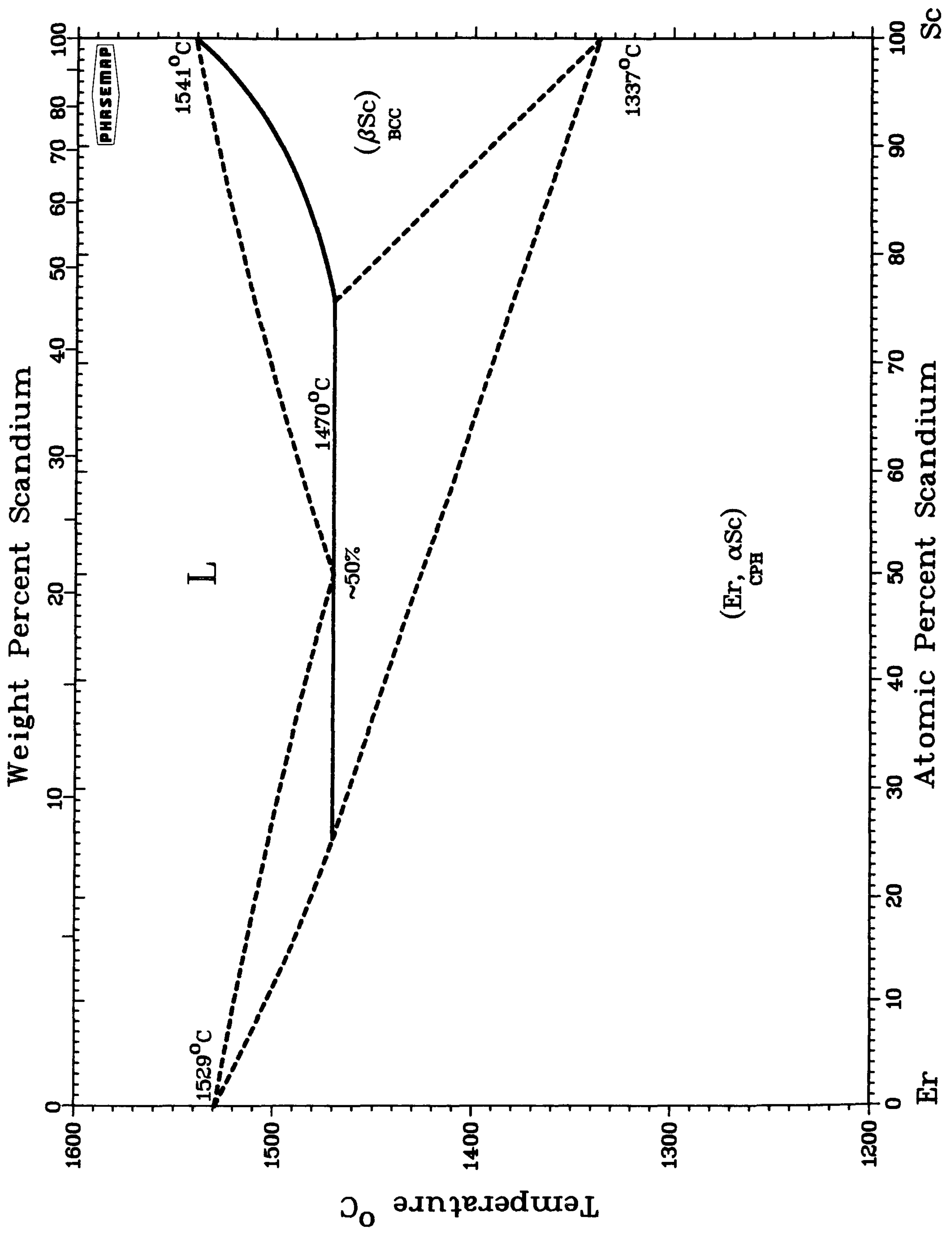
J.L. Murray; evaluation on p 81 in this issue.
J.L. Murray is Category Editor for binary titanium alloys.



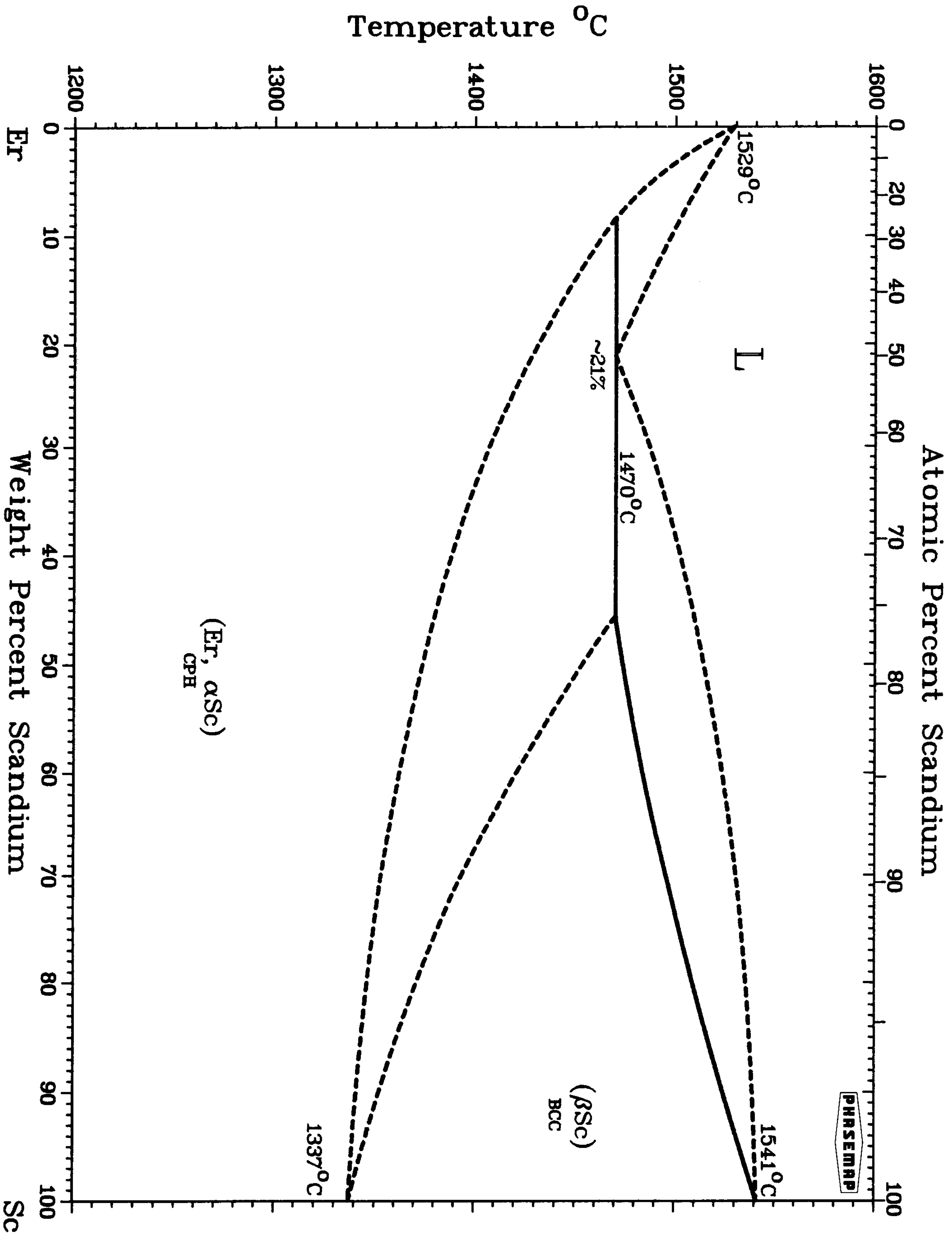
K. A. Gschneidner, Jr. and **F. W. Calderwood**; evaluation on p 74 in this issue.
K. A. Gschneidner, Jr. is Category Editor for binary rare-earth alloys.



K. A. Gschneidner, Jr. and **F. W. Calderwood**; evaluation on p 74 in this issue.
K. A. Gschneidner, Jr. is Category Editor for binary rare-earth alloys.



K. A. Gschneidner, Jr. and F. W. Calderwood; evaluation on p 75 in this issue.
K. A. Gschneidner, Jr. is Category Editor for binary rare-earth alloys.



K. A. Gschneidner, Jr. and **F. W. Calderwood;** evaluation on p 75 in this issue.
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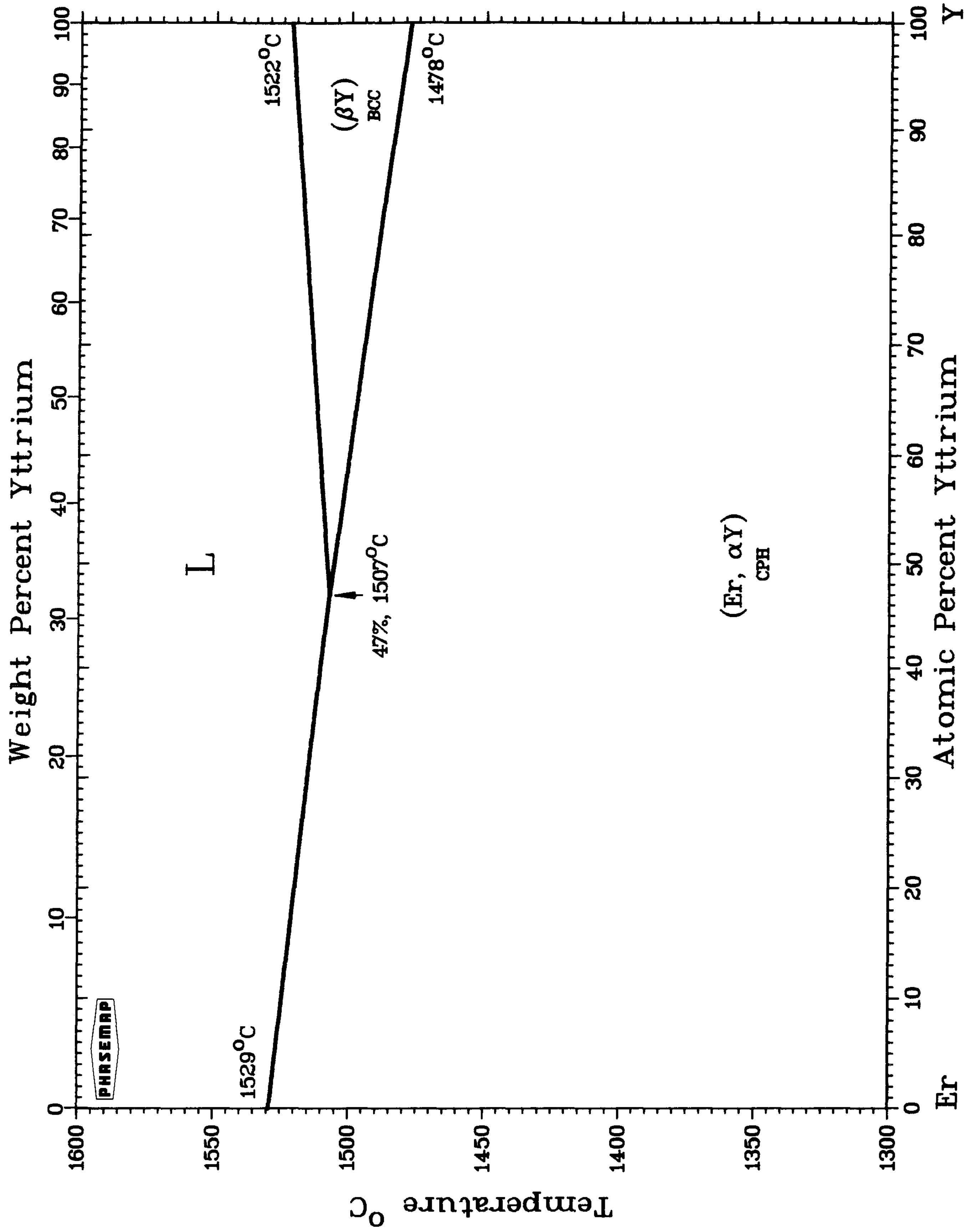
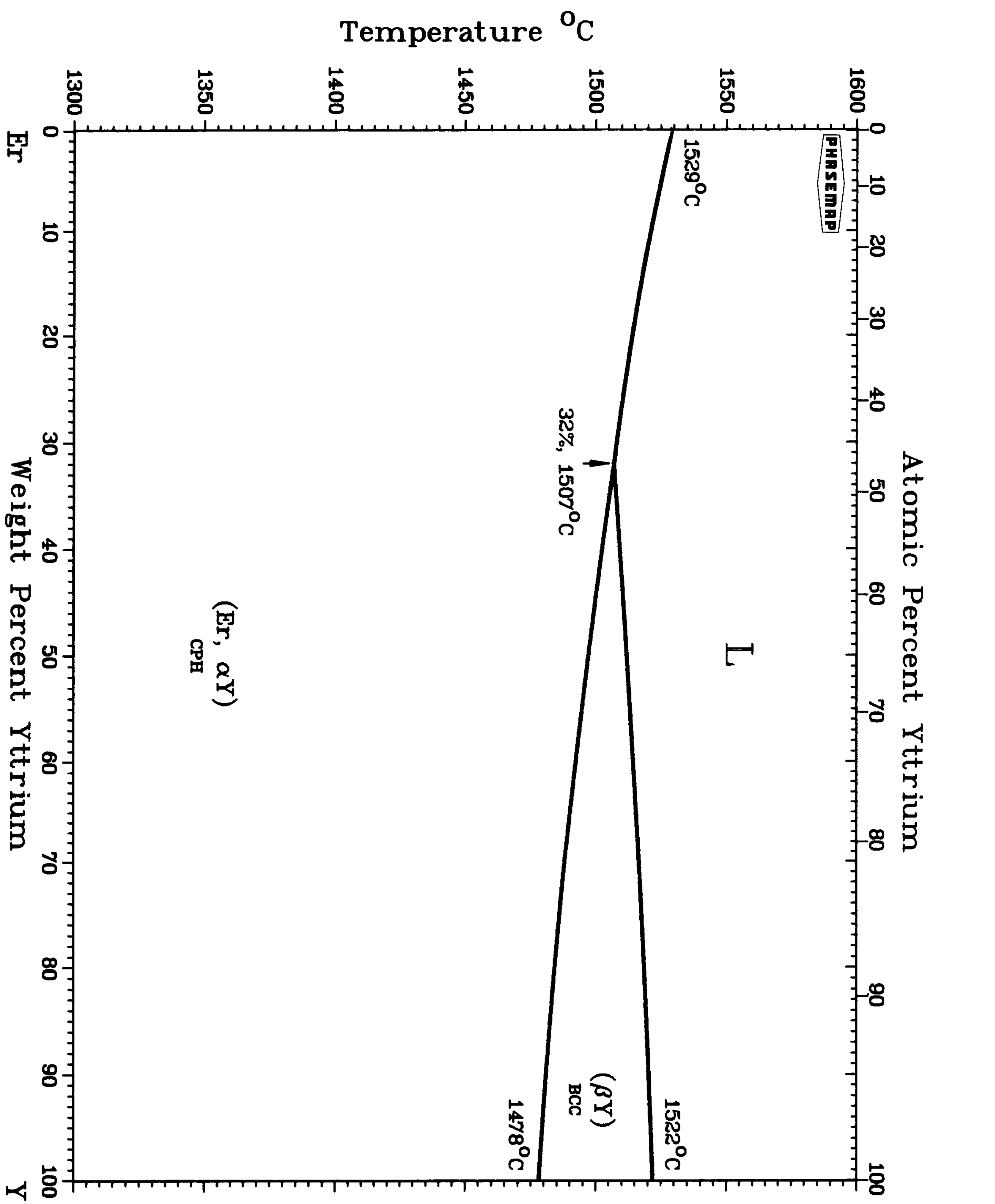
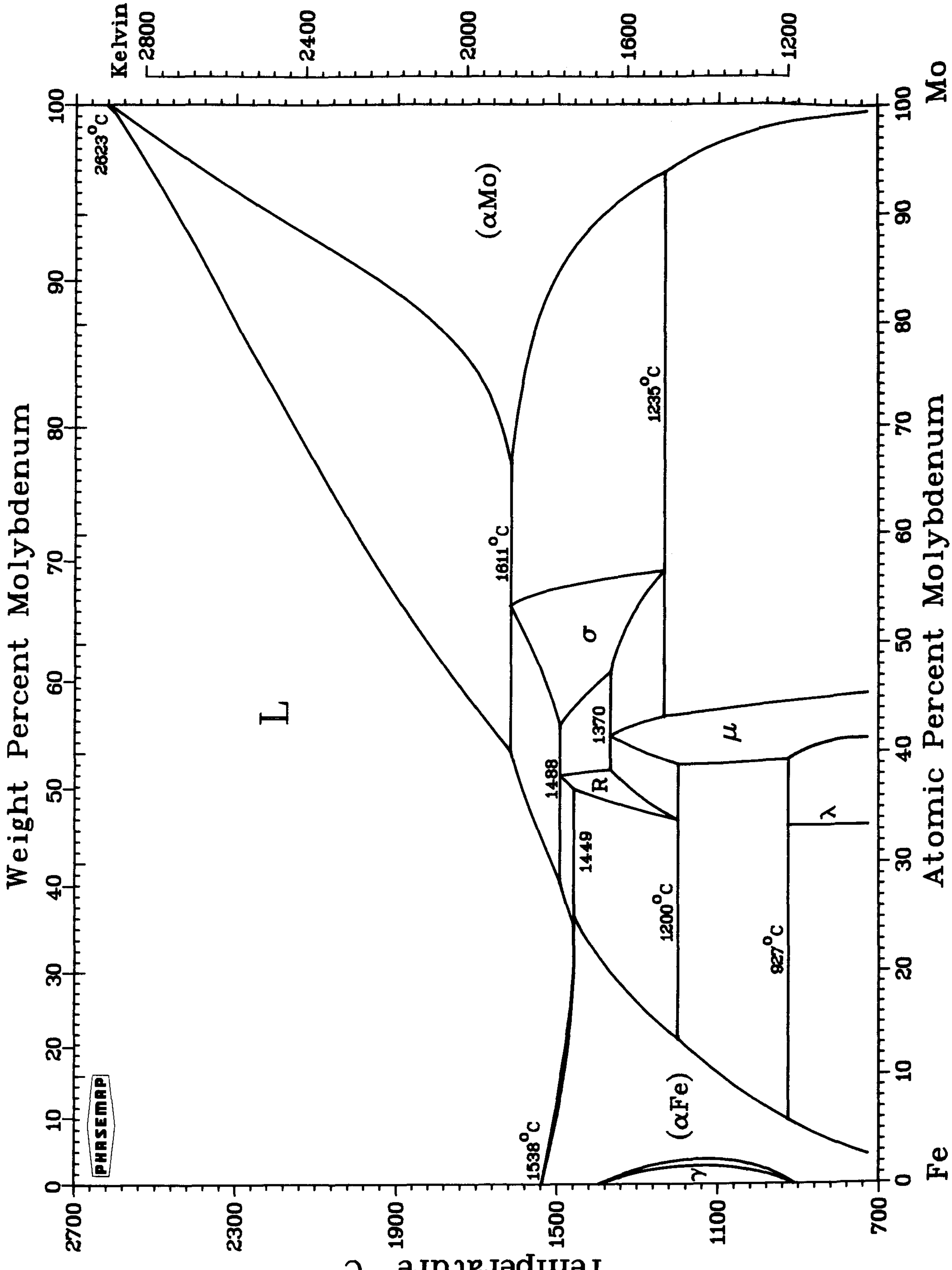


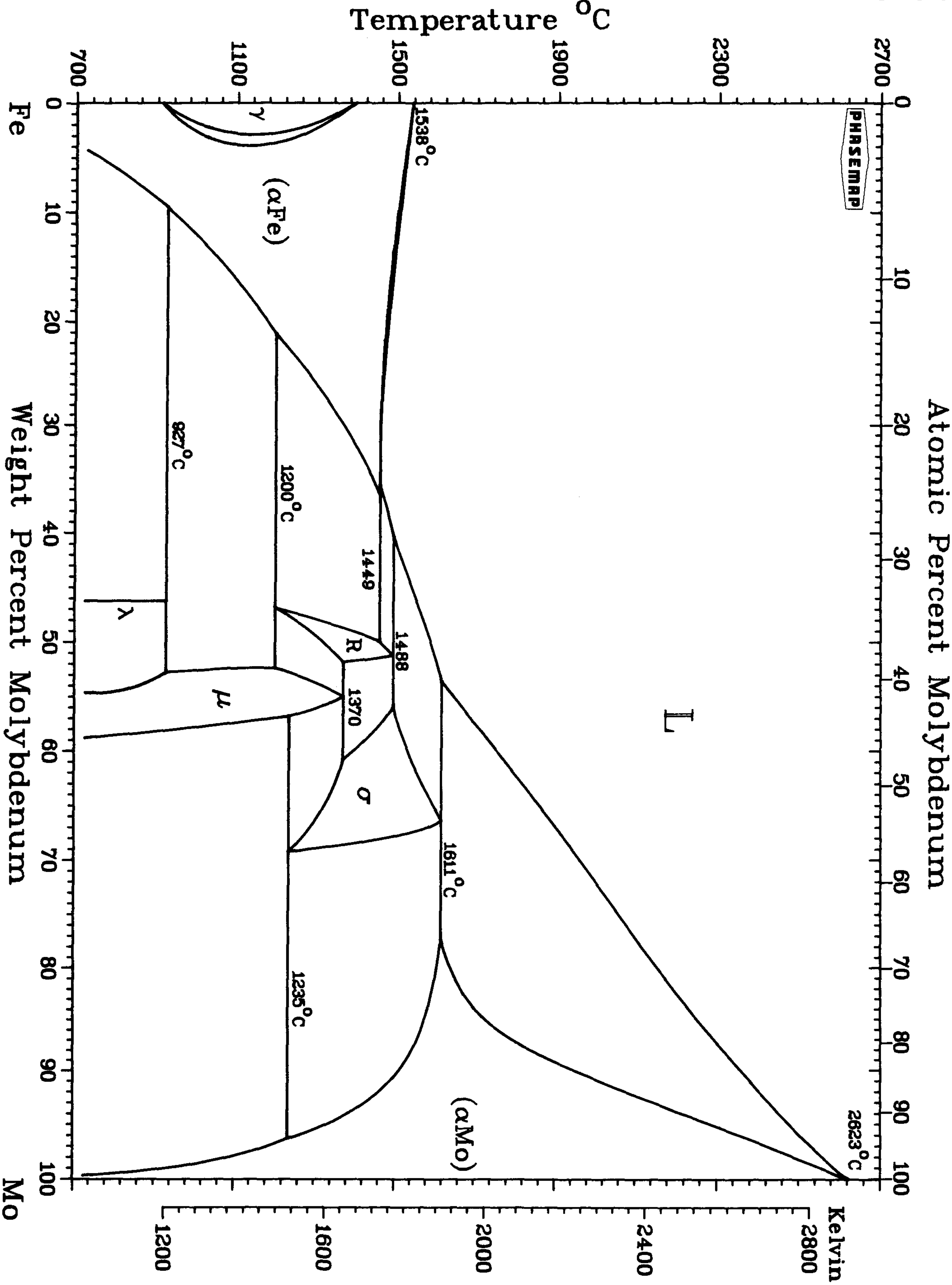
K. A. Gschneidner, Jr. and **F. W. Calderwood;** evaluation on p 77 in this issue.
K. A. Gschneidner, Jr. is Category Editor for binary rare-earth alloys.



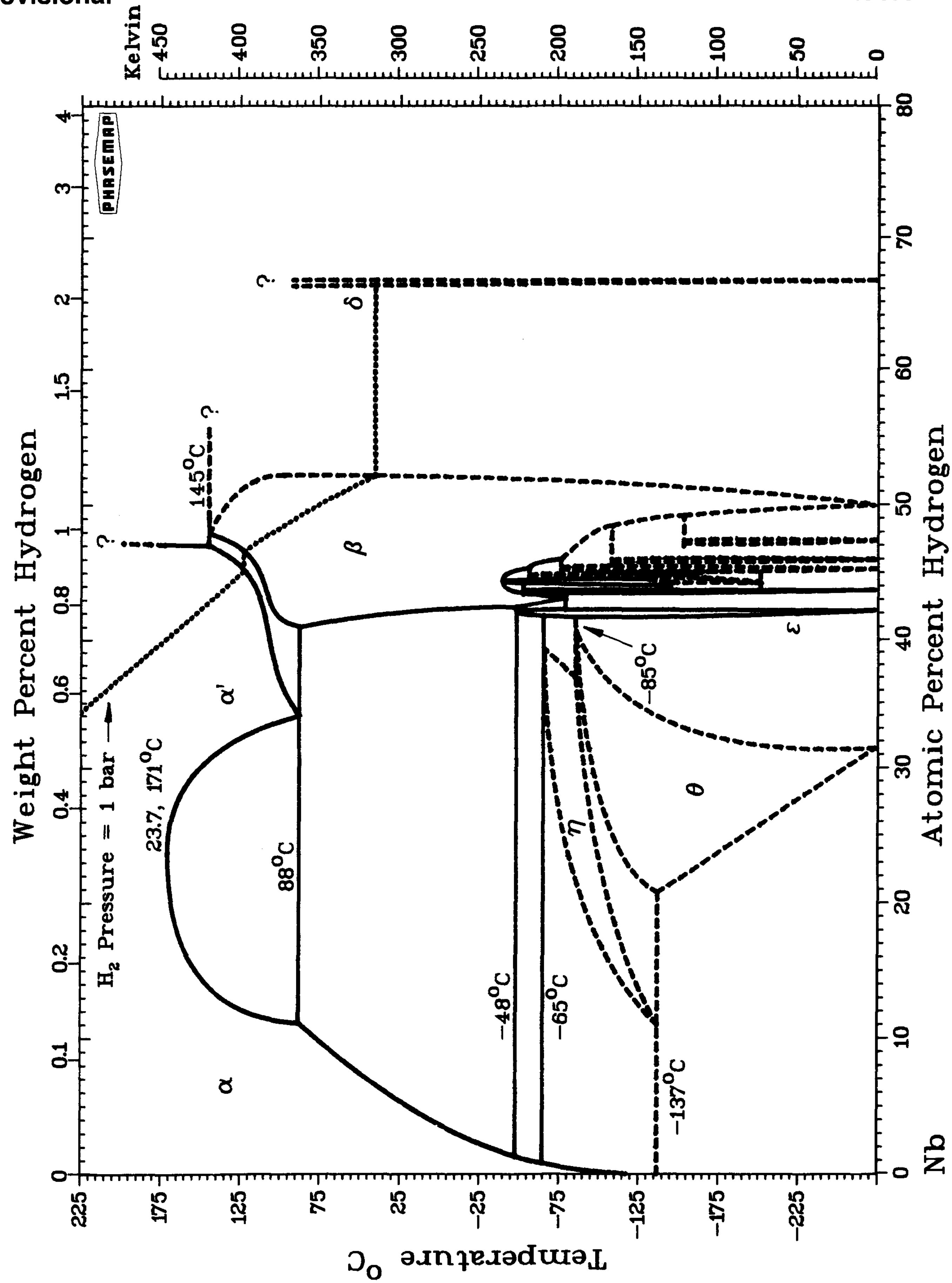
K. A. Gschneidner, Jr. and **F. W. Calderwood;** evaluation on p 77 in this issue.
K. A. Gschneidner, Jr. is Category Editor for binary rare-earth alloys.



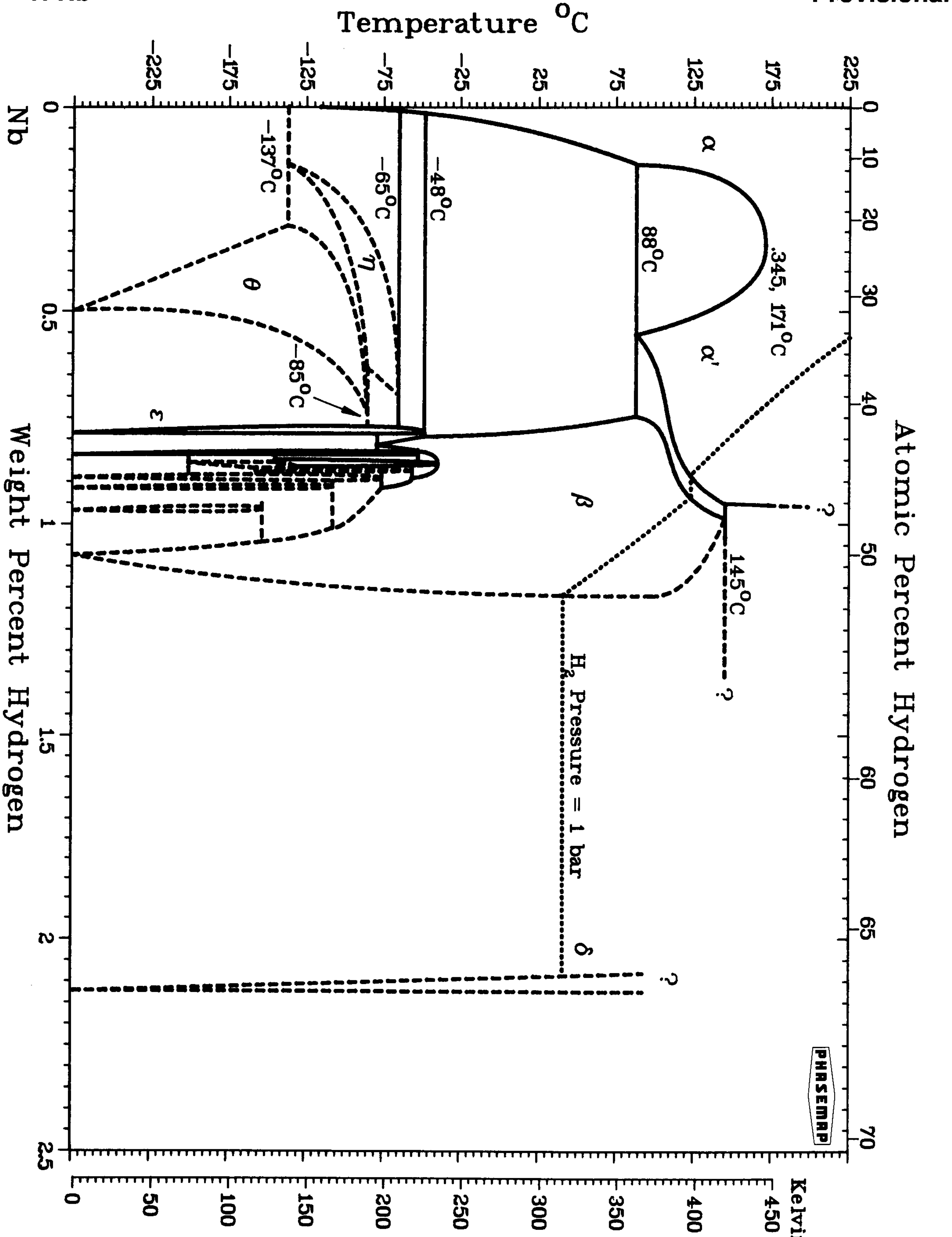
A. Fernández Guillermet; evaluation on p 359 in Vol. 3, No. 3.
(See also Comments and Addenda, p 28 in this issue.)



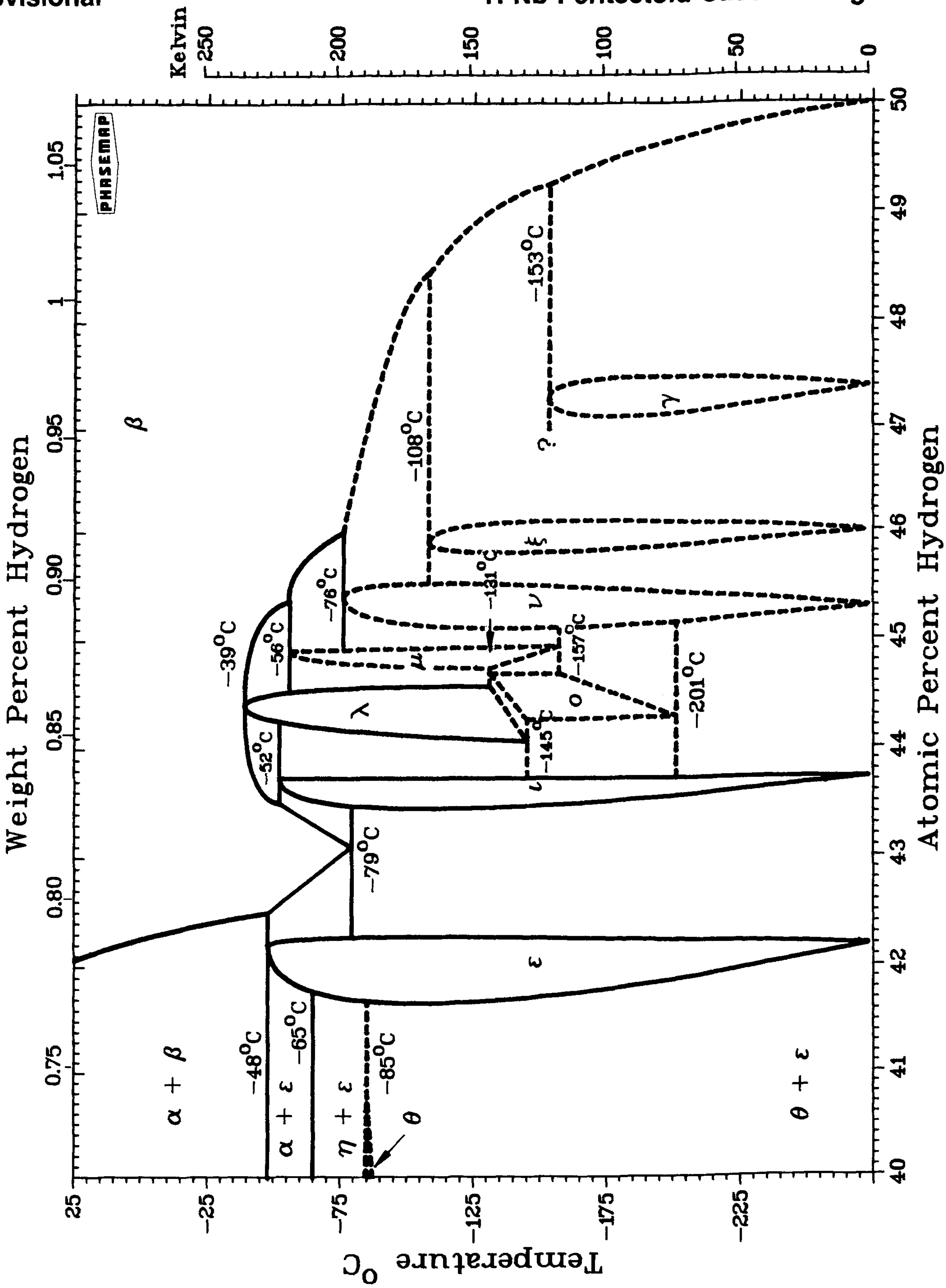
A. Fernández Guillermet; evaluation on p 359 in Vol. 3, No. 3.
(See also Comments and Addenda, p 28 in this issue.)



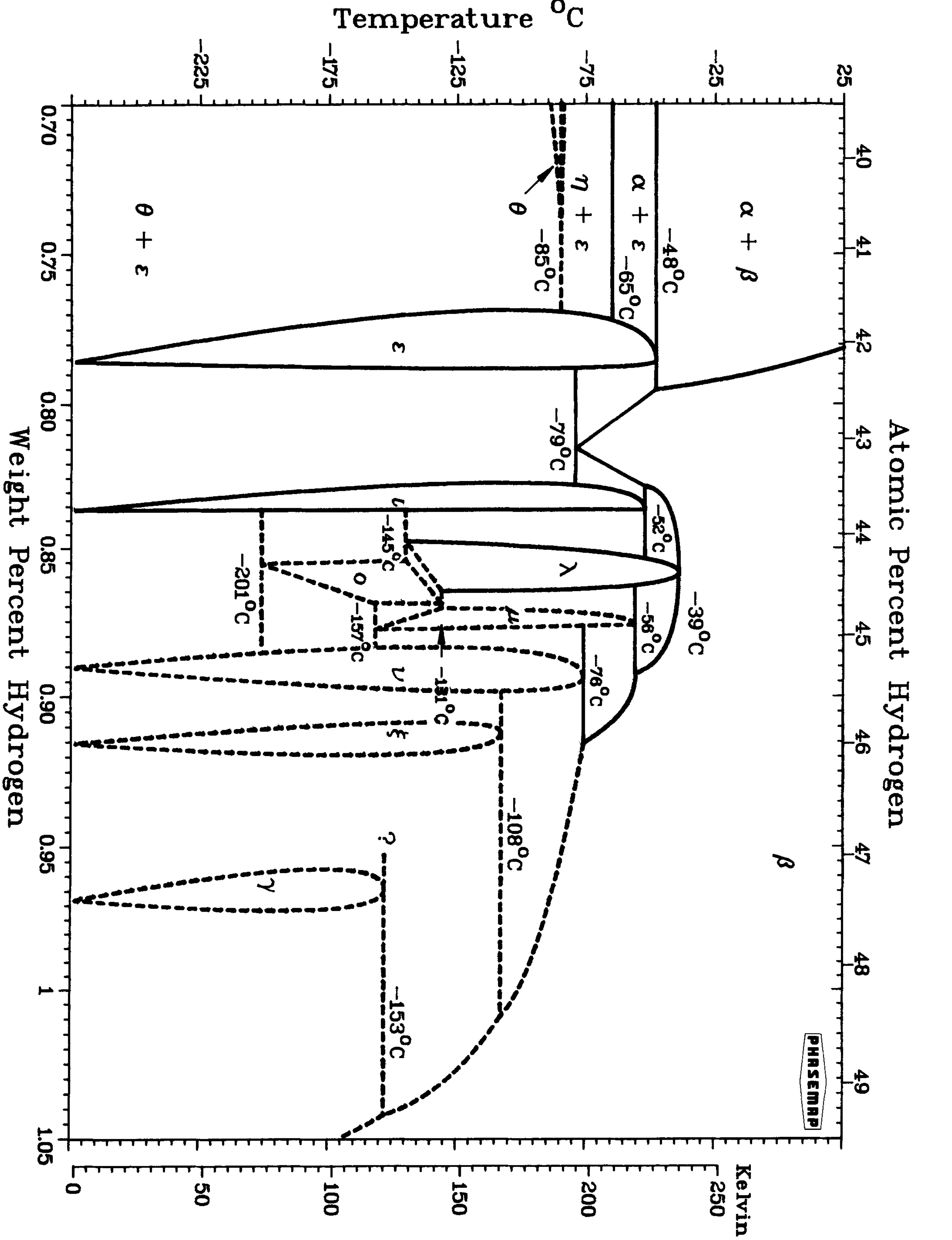
J. F. Smith; evaluation on p 39 in this issue.
J. F. Smith is Co-Category Editor for binary niobium alloys.



J. F. Smith; evaluation on p 39 in this issue.
J. F. Smith is Co-Category Editor for binary niobium alloys.



J. F. Smith; evaluation on p 39 in this issue.
J. F. Smith is Co-Category Editor for binary niobium alloys.



J. F. Smith; evaluation on p 39 in this issue.
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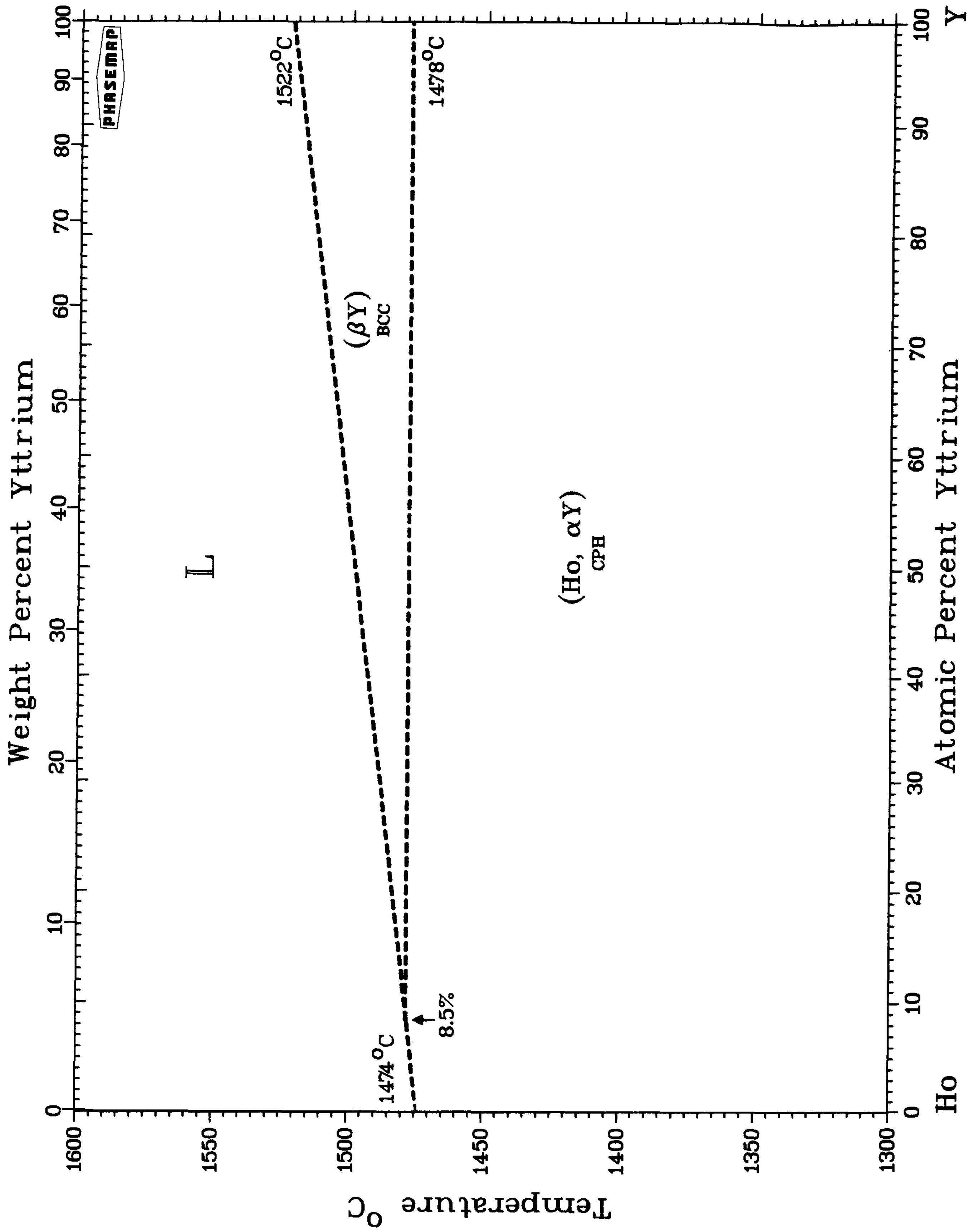
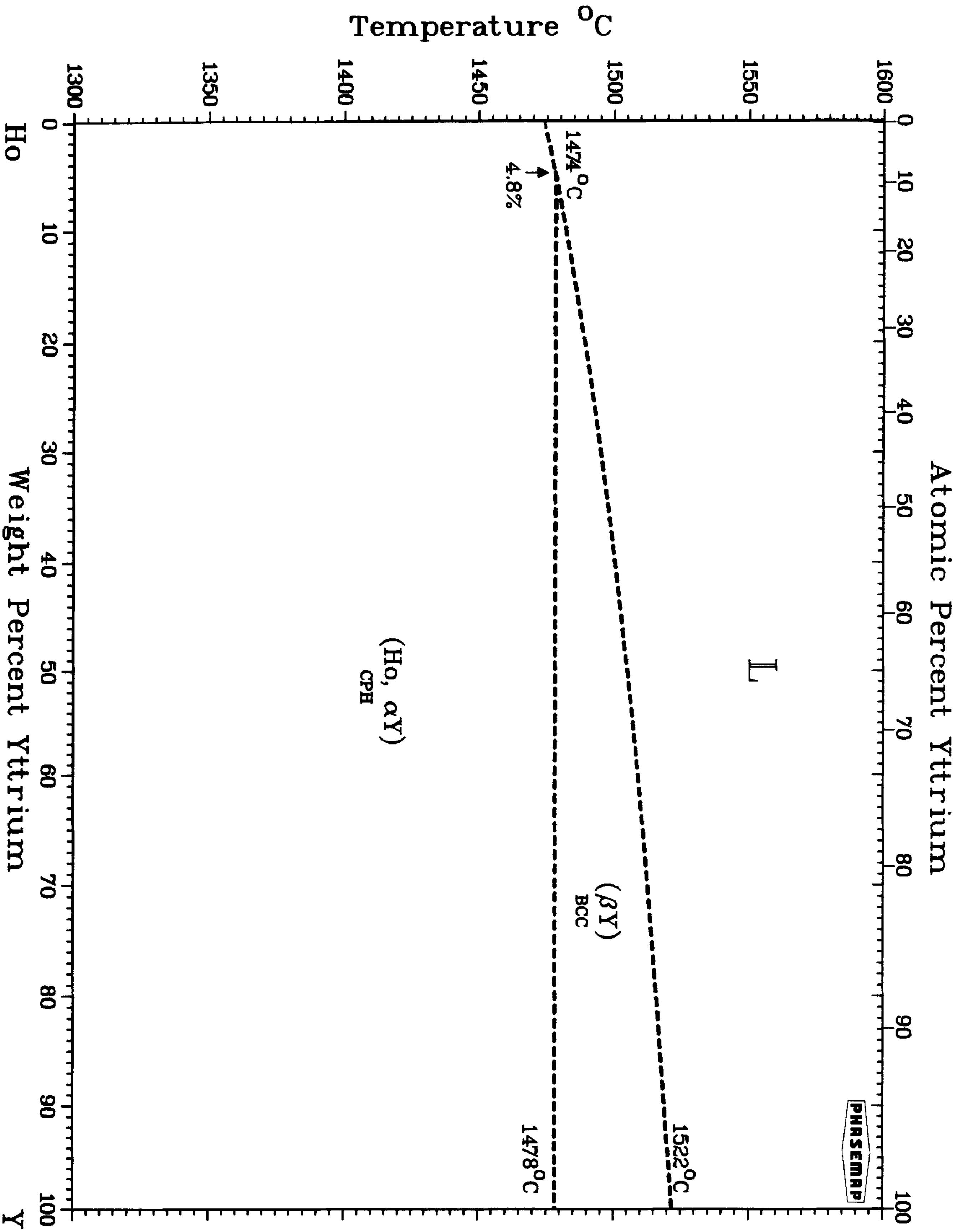
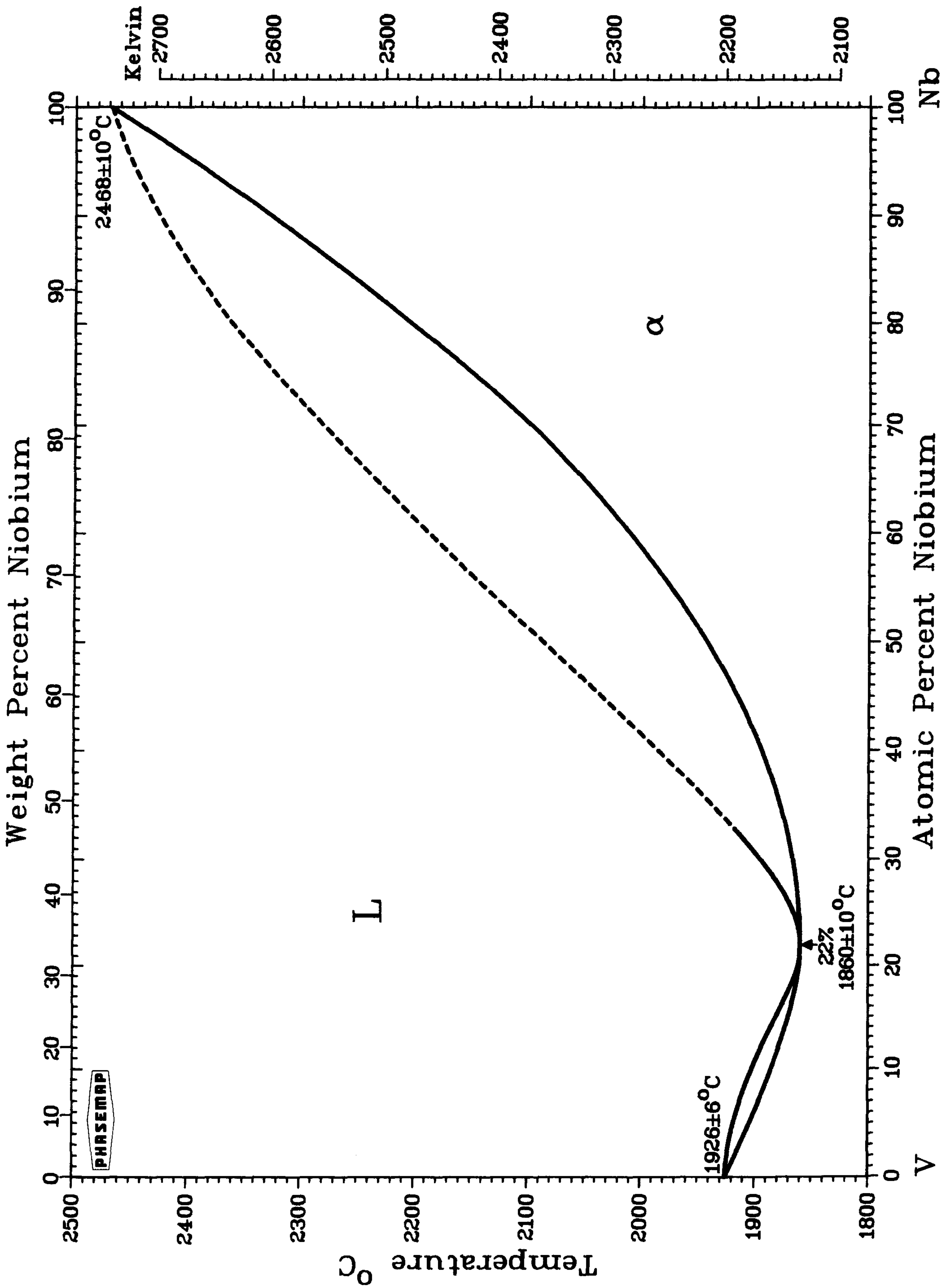


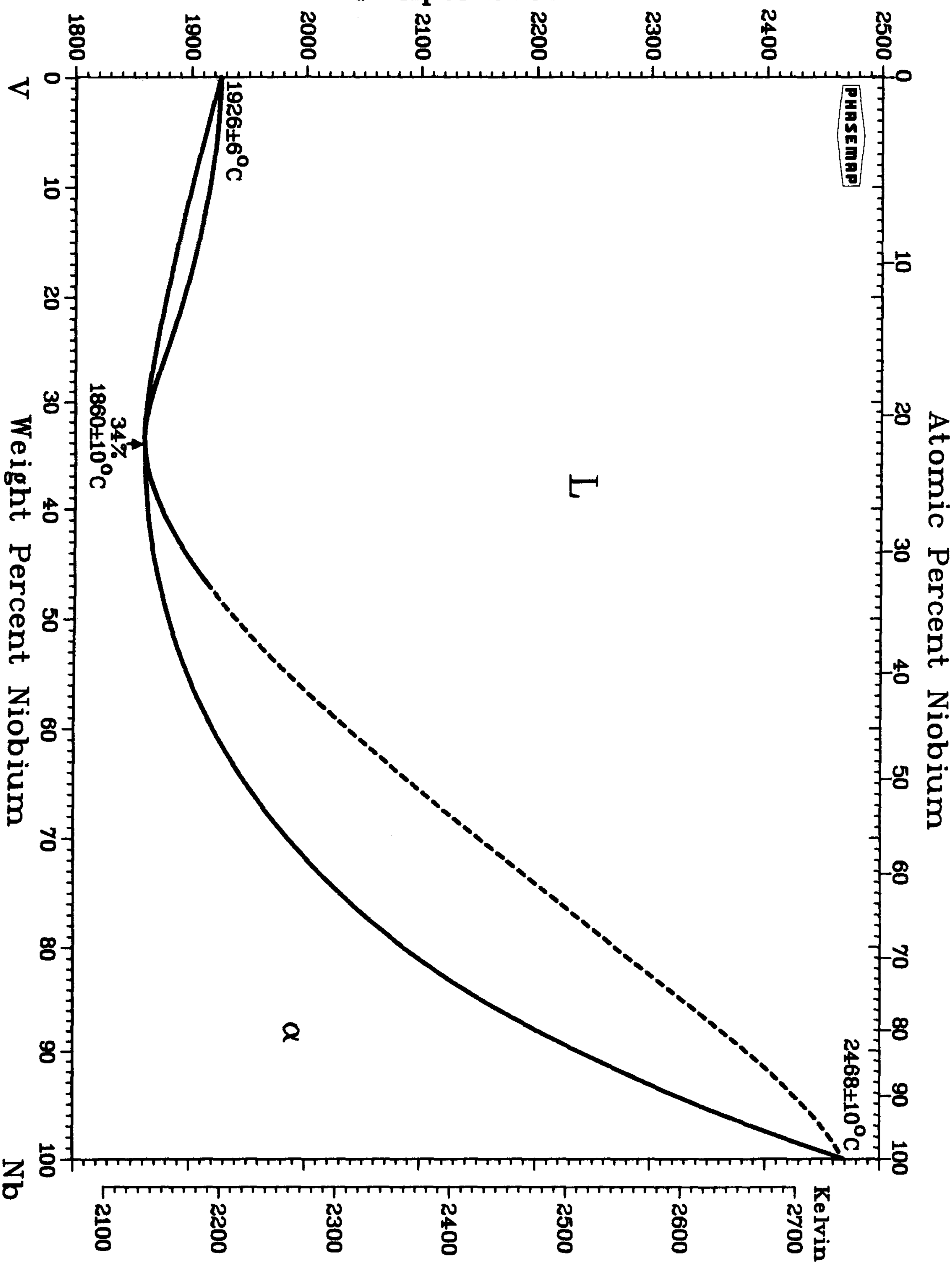
K. A. Gschneidner, Jr. and **F. W. Calderwood**; evaluation on p 80 in this issue.
K. A. Gschneidner, Jr. is Category Editor for binary rare-earth alloys.



K. A. Gschneidner, Jr. and **F. W. Calderwood**; evaluation on p 80 in this issue.
K. A. Gschneidner, Jr. is Category Editor for binary rare-earth alloys.



J. F. Smith and **O. N. Carlson;** evaluation on p 46 in this issue.
J. F. Smith is Category Editor for binary vanadium alloys and Co-Category Editor for binary niobium alloys.



J. F. Smith and **O. N. Carlson;** evaluation on p 46 in this issue.
J. F. Smith is Category Editor for binary vanadium alloys and Co-Category Editor for binary niobium alloys.

Heats of Transition of the Elements

See reverse for explanation and for transition temperatures of the phases

Key

Key	
Fe 26	← Chemical symbol, ← Atomic number
13 807	← Enthalpy (ΔH), L ⇄ S, J/mol of atoms
837 900	← Enthalpy (ΔH), S ⇄ S, J/mol of atoms

	I A (Alkali Metals)	II A (Alkaline Earth Metals)	III A	IV A	V A	VI A	VII A	VIII A	IX A	X A	I B	II B	III B	IV B	V B (Pnictide Elements)	VI B (Chalcogens)	VII B (Halogens)	Inert Gases
1	H 1 58.68																	He 2
2	Li 3 3 000	Be 4 (12 600) (2 100)											B 5 50 200	C 6	N 7 360.4 116	O 8 223 371.3 48.4	F 9 255 364	Ne 10 331.7
3	Na 11 2 600	Mg 12 8 477											Al 13 10 700	Si 14 50 210	P 15 629 (white α)	S 16 1 718 402	Cl 17 3 203	Ar 18 1 190
4	K 19 2 320	Ca 20 8 540 842	Sc 21 14 100 4 010	Ti 22 14 150 4 170	V 23 22 845	Cr 24 (20 500)	Mn 25 (12 060) 1 880 2 120 2 230	Fe 26 13 800 840 900	Co 27 16 200 450	Ni 28 17 470	Cu 29 13 050	Zn 30 7 320	Ga 31 5 565	Ge 32 37 030	As 33	Se 34 6 700	Br 35 5 286	Kr 36 1 638
5	Rb 37 2 190	Sr 38	Y 39 11 400 4 990	Zr 40 20 920 4 015	Nb 41 26 900	Mo 42 35 980	Tc 43	Ru 44 (24 280)	Rh 45 (21 490)	Pd 46 (17 560)	Ag 47 11 300	Cd 48 6 200	In 49 3 280	Sn 50 7 195	Sb 51 19 900	Te 52 17 490	I 53 7 820	Xe 54 2 300
6	Cs 55 2 095	Ba 56 7 120	La-Lu	Hf 72 (29 300) 5 910	Ta 73 36 570	W 74 46 000	Re 75 (33 230)	Os 76 (31 800)	Ir 77 (26 140)	Pt 78 (19 650)	Au 79 13 000	Hg 80 2 295	Tl 81 4 200 360	Pb 82 4 800	Bi 83 11 300	Po 84	At 85	Rn 86 (2 890)
7	Fr 87	Ra 88	Ac-Lr															

Transition Metals: III A – X A

Lanthanide Metals

La 57 6 200 3 120 360	Ce 58 5 460 2 990 190 1 950	Pr 59 6 890 3 170	Nd 60 7 140 3 030	Pm 61 (7 550) (2 900)	Sm 62 8 620 3 110	Eu 63 9 210	Gd 64 10 050 3 910	Tb 65 10 800 5 020	Dy 66 11 060 4 160	Ho 67 (16 900)	Er 68 19 900	Tm 69 16 840	Yb 70 7 660 1 750	Lu 71 (18 650)

Actinide Metals

Ac 89	Th 90 13 807 3 599	Pa 91 12 340 6 640	U 92 9 142 4 757 2 791	Np 93 5 190 5 270 5 605	Pu 94 2 825 1 840 80 585 565 3 375	Am 95 14 395 5 860 775	Cm 96 14 645 3 245	Bk 97	Cf 98	Es 99	Fm 100	Md 101	No 102	Lr 103

Heats of Transition of the Elements

By M. W. Chase
Dow Chemical Company

The transition properties listed below and on the reverse of this tear-out page were selected from several critical evaluations of data. All values, given in J mol^{-1}, are for one gram-atom of substance at the standard state pressure of 1 atmosphere (1.01325 bar). ΔH represents the heat absorbed when transforming from the lower temperature phase to the higher temperature phase, or the heat evolved when transforming from the higher to the lower temperature phase. Values that appear in parentheses are estimates or extrapolations. The significant figures shown are a guide to relative accuracy.

Footnotes to Table

(a) Triple point values, which are defined fixed points of IPTS-68. **(b)** Melting points or freezing points, which are defined fixed points of IPTS-68. **(c)** Triple point values, which are secondary reference points of IPTS-68. **(d)** Melting points or freezing points, which are secondary reference points of IPTS-68.

References

[1] Private communication from K. A. Gschneidner, Jr. (1983), Ce($\beta \rightleftarrows \gamma$). **[2]** Gschneidner, K. A., Jr., and Beaudry, B. J., *Metals Handbook*, 9th ed., Vol. 2, ASM, Metals Park, OH, p 738 (Ho data) and p 788 (Pm data) (1979). **[3]** Oetting, F. L., Rand, M. H., and Ackermann, R. J., *The Chemical Thermodynamics of Actinide Elements and Compounds*, Part 1, *The Actinide Elements*, International Atomic Energy Agency, Vienna (1976), Th, Pa, U, Np, Pu, Am, and Cm data. **[4]** Hultgren, R., *et al.*, *Selected Values of the Thermodynamic Properties of the Elements*, ASM, Metals Park, OH (1973). **[5a]** Stull, D. R. and Prophet, H., *The JANAF Thermochemical Tables*, 2nd ed., NSRDS-NBS 37, U.S. GPO, Washington, DC (1971); **[5b]** Chase, M. W., *et al.*, "1974 Supplement", *J. Phys. Chem. Ref. Data, 3*, p 311-480 (1974); **[5c]** "1975 Supplement", *J. Phys. Chem. Ref. Data, 4*, p 1-175 (1975); **[5d]** "1978 Supplement", *J. Phys. Chem. Ref. Data, 7*, p 793-940 (1978); **[5e]** "1981 Supplement"; **[5f]** Third Edition, to be published. **[6]** Glushko, V. P., *et al.*, *Termicheskii Konstanty Veshchestv*, Viniti, Moscow, Vol. 1 (1965) to Vol. 10 (1982). **[7]** Glushko, V. P., *et al.*, *Termodinamecheskie Svoistva Individual'nykh Veshchestv*, Viniti, Moscow, Vol. 1 (1978) to Vol. 4 (1982).

Contributed by **Dr. Malcolm W. Chase**, 1707 Bldg., The Dow Chemical Company, Midland, MI 48640.

Element	Atomic number	Transformation	Enthalpy (ΔH), J/mol	Temperature, °C
Ag	47	$L \rightleftarrows S$	11 300	961.93(b)
Al	13	$L \rightleftarrows S$	10 700	660.457(d)
Am	95	$L \rightleftarrows \gamma$	14 395	1176
		$\gamma \rightleftarrows \beta$	5 860	1077
		$\beta \rightleftarrows \alpha$	775	650
Ar	18	$L \rightleftarrows S$	1 190	83.798 K(a)
Au	79	$L \rightleftarrows S$	13 000	1064.43(b)
B	5	$L \rightleftarrows \beta$	50 200	2077
Ba	56	$L \rightleftarrows S$	7 120	727
Be	4	$L \rightleftarrows \beta$	(12 600)	1287
		$\beta \rightleftarrows \alpha$	(2 100)	1277
Bi	83	$L \rightleftarrows S$	11 300	271.442(c)
Br	35	$L \rightleftarrows S$	5 286	265.9 K
Ca	20	$L \rightleftarrows \beta$	8 540	842
		$\beta \rightleftarrows \alpha$	842	443
Cd	48	$L \rightleftarrows S$	6 200	321.108(d)
Ce	58	$L \rightleftarrows \delta$	5 460	800
		$\delta \rightleftarrows \gamma$	2 990	725
		$\gamma \rightleftarrows \beta$	190	...
		$\beta \rightleftarrows \alpha$	1 950	...
Cl	17	$L \rightleftarrows S$	3 203	172.16 K
Cm	96	$L \rightleftarrows \beta$	14 645	1345
		$\beta \rightleftarrows \gamma$	3 245	1277
Co	27	$L \rightleftarrows \beta$	16 200	1495(d)
		$\beta \rightleftarrows \alpha$	450	427
Cr	24	$L \rightleftarrows S$	(20 500)	1857
Cs	55	$L \rightleftarrows S$	2 090	28.44
Cu	29	$L \rightleftarrows S$	13 050	1084.88(d)
Dy	66	$L \rightleftarrows \beta$	11 060	1409
		$\beta \rightleftarrows \alpha$	4 160	1385
Er	68	$L \rightleftarrows S$	19 900	1522
Eu	63	$L \rightleftarrows S$	9 210	817
F	9	$L \rightleftarrows \beta$	255	53.48 K
		$\beta \rightleftarrows \alpha$	364	45.55 K
Fe	26	$L \rightleftarrows \delta$	13 800	1535(d)
		$\delta \rightleftarrows \gamma$	840	1392
		$\gamma \rightleftarrows \alpha$	900	911
Ga	31	$L \rightleftarrows S$	5 565	29.771(d)
Gd	64	$L \rightleftarrows \beta$	10 050	1312
		$\beta \rightleftarrows \alpha$	3 910	1260
Ge	32	$L \rightleftarrows S$	37 030	937
H	1	$L \rightleftarrows S$	58.68	13.81 K(a)
Hf	72	$L \rightleftarrows S$	(29 300)	2227
		$\beta \rightleftarrows \alpha$	(5 910)	1781
Hg	80	$L \rightleftarrows \alpha$	2 295	−38.836(d)
Ho	67	$L \rightleftarrows \beta$	(16 900)	1470
I	53	$L \rightleftarrows S$	7 820	113.5
In	49	$L \rightleftarrows S$	3 280	156.634(d)
Ir	77	$L \rightleftarrows S$	(26 140)	2447(d)
K	19	$L \rightleftarrows S$	2 320	63.71
Kr	36	$L \rightleftarrows S$	1 638	115.770 K(c)
La	57	$L \rightleftarrows \gamma$	6 200	920
		$\gamma \rightleftarrows \beta$	3 120	860
		$\beta \rightleftarrows \alpha$	360	275
Li	3	$L \rightleftarrows \beta$	3 000	180.54
Lu	71	$L \rightleftarrows S$	(18 650)	1663
Mg	12	$L \rightleftarrows S$	8 477	650
Mn	25	$L \rightleftarrows \delta$	(12 060)	1245
		$\delta \rightleftarrows \gamma$	1 880	1135
		$\gamma \rightleftarrows \beta$	2 120	1085
		$\beta \rightleftarrows \alpha$	2 230	700
Mo	42	$L \rightleftarrows S$	35 980	2623(d)
N	7	$L \rightleftarrows \beta$	360.4	63.146 K(c)
		$\beta \rightleftarrows \alpha$	116	35.61 K
Na	11	$L \rightleftarrows \beta$	2 600	97.86
Nb	41	$L \rightleftarrows S$	(26 900)	2473(d)
Nd	60	$L \rightleftarrows \beta$	7 140	1015
Nd	60	$\beta \rightleftarrows \alpha$	3030	855
Ne	10	$L \rightleftarrows S$	331.7	24.561 K(c)
Ni	28	$L \rightleftarrows S$	17 470	1455(d)
Np	93	$L \rightleftarrows \gamma$	5 190	639
		$\gamma \rightleftarrows \beta$	5 270	576
		$\beta \rightleftarrows \alpha$	5 605	280
O	8	$L \rightleftarrows \gamma$	223	54.361 K(a)
		$\gamma \rightleftarrows \beta$	371.3	43.801 K
		$\beta \rightleftarrows \alpha$	48.4	23.867 K
Os	76	$L \rightleftarrows S$	(31 800)	3025
P(white α)	15	$L \rightleftarrows \alpha$	629	44
Pa	91	$L \rightleftarrows \beta$	12 340	1572
		$\beta \rightleftarrows \alpha$	6 640	1170
Pb	82	$L \rightleftarrows S$	4 800	327.502(d)
Pd	46	$L \rightleftarrows S$	(17 560)	1554(d)
Pm	61	$L \rightleftarrows S$	(7 550)	...
		$\beta \rightleftarrows \alpha$	(2 900)	...
Pr	59	$L \rightleftarrows \beta$	6 890	930
		$\beta \rightleftarrows \alpha$	3 170	795
Pt	78	$L \rightleftarrows S$	(19 650)	1769(d)
Pu	94	$L \rightleftarrows \varepsilon$	2 825	640
		$\varepsilon \rightleftarrows \delta'$	1 840	479
		$\delta' \rightleftarrows \delta$	80	457
		$\delta \rightleftarrows \gamma$	585	315
		$\gamma \rightleftarrows \beta$	565	207
		$\beta \rightleftarrows \alpha$	3 375	122
Rb	37	$L \rightleftarrows S$	2 190	39.32
Re	75	$L \rightleftarrows S$	(33 230)	3180
Rh	45	$L \rightleftarrows S$	(21 490)	1963(d)
Rn	86	$L \rightleftarrows S$	(2 890)	−71
Ru	44	$L \rightleftarrows S$	(24 280)	2250
S	16	$L \rightleftarrows \beta$	1 718	115
		$\beta \rightleftarrows \alpha$	402	95
Sb	51	$L \rightleftarrows S$	19 900	630.775(d)
Sc	21	$L \rightleftarrows \beta$	14 100	1539
		$\beta \rightleftarrows \alpha$	4 010	1335
Se	34	$L \rightleftarrows S$	6 700	220
Si	14	$L \rightleftarrows S$	50 210	1417
Sm	62	$L \rightleftarrows \beta$	8 620	1072
		$\beta \rightleftarrows \alpha$	3 110	917
Sn	50	$L \rightleftarrows \beta$	7 195	231.9681(b)
Sr	38	$L \rightleftarrows \gamma$	7 431	777
		$\gamma \rightleftarrows \alpha$	837	547
Ta	73	$L \rightleftarrows S$	36 570	2985
Tb	65	$L \rightleftarrows \beta$	10 800	1355
		$\beta \rightleftarrows \alpha$	5 020	1285
Te	52	$L \rightleftarrows S$	17 490	449.5
Th	90	$L \rightleftarrows \beta$	13 807	1750
		$\beta \rightleftarrows \alpha$	3 599	1360
Ti	22	$L \rightleftarrows \beta$	14 150	1663
		$\beta \rightleftarrows \alpha$	4 170	893
Tl	81	$L \rightleftarrows \beta$	4 200	303
		$\beta \rightleftarrows \alpha$	360	234
Tm	69	$L \rightleftarrows S$	16 840	1545
U	92	$L \rightleftarrows \gamma$	9 142	1135
		$\beta \rightarrow \gamma$	4 757	776
		$\alpha \rightarrow \beta$	2 791	669
V	23	$L \rightleftarrows S$	22 845	1917
W	74	$L \rightleftarrows S$	46 000	3422(d)
Xe	54	$L \rightleftarrows S$	2 300	161.388 K(c)
Y	39	$L \rightleftarrows \beta$	11 400	1525
		$\beta \rightleftarrows \alpha$	4 990	1480
Yb	70	$L \rightleftarrows \beta$	7 660	824
		$\beta \rightleftarrows \alpha$	1 750	760
Zn	30	$L \rightleftarrows S$	7 320	419.58(b)
Zr	40	$L \rightleftarrows \beta$	20 920	1855(d)
		$\beta \rightleftarrows \alpha$	4 015	862